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A SERMONETTE

Homer W. Le Sourd

Formerly lecturer, Harvard Graduate School of Education

Text——"Be Prepared"

Teachers are compelled to make frequent use of this text. Rarely, however, does a pupil venture to admonish his teacher to go and do likewise, but let no teacher assume that his own lack of preparation has escaped the notice of his pupils.

What constitutes A-1 preparation of a science teacher? Four years of college science plus two years of graduate study in the special field in which he will teach is recommended as ideal background, but unfortunately science instruction in American high schools can not await the glad day when such preparation is the accepted standard.

"If ye don't have no education, ye jes got to use your head."* This bit of wisdom can be applied to the making of a teacher. Lack of adequate background can be remedied if the teacher, while in service, devotes himself diligently to the study of school and college texts and to the constant reading of current scientific literature.

Much depends on the conscientious day-by-day preparation which the teacher makes. In addition to the serious study of the fundamentals of his subject he should give considerable attention to the assembling of interesting facts, stories, biographical incidents and novel applications of science in order to stimulate his pupils to think and to appreciate.

To be effective, this material must be organized into a definite, prearranged pattern in much the same manner that a minister prepares his sermon or a lawyer his brief. Such an outline avoids two equally bad faults,—sticking too close to the text book or wandering aimlessly too far from it.

* Supposed to have been said by an illiterate mountaineer.

"The "morgue" of a newspaper contains obituary material collected in advance of the occasion for its use. In like manner a teacher can gradually accumulate his own back-log of scientific material for presentation at the appropriate time. This stock-in-trade will include pamphlets, magazine articles, newspaper clippings, reading and lecture notes, references, pictures, diagrams, problems, and other illustrative matter, filed in orderly fashion and available for use at a moment's notice.

A filing case is an essential part of this plan. A very convenient type of container for clippings is the "vertical file folder," letter size (9×12). This opens out flat so as to expose its contents fully, and for this reason it is more convenient than an envelope.

Incidentally, one soon discovers numerous uses for his filing cabinet apart from the storage of scientific material. It takes care of all sorts of clippings, personal correspondence, circulars, reports, programs, pictures, and other things of personal interest.

Conclusion

The formula for successful class-room performance is a complicated one, but it certainly includes these three important factors,—a consistent program of scientific reading by the teacher, a systematic plan for filing away the results of his reading, and the development of a carefully considered outline for each class-room session.

THE QUIZ SECTION

Julius Sumner Miller
Dillard University, New Orleans 19, Louisiana

1. A rope passes over a single fixed pulley (negligible weight). Two men, A and B, of equal weight, hang on to the free ends. A climbs up with a velocity V. What happens to B if he just holds on?

2. Two men standing on a flat-car are playing ball while the car moves at a uniform velocity. (They are throwing the ball back and forth between them.) Which man does more work?

3. A man of mass M_2 sits in the stern of a boat of mass M_1 and length L. The boat is at rest. He rises and walks to the bow. How far does the boat move while he walks the length of it?

4. Two racing cars pass the starting-point at the same instant with velocities V_1 and V_2 and travel on a straight course with uniform accelerations A_1 and A_2. They tie in the race. Find the length of the course.

5. Two weights W_1 and W_2 are connected by a string which passes over a pulley at the top of a smooth plane inclined 30° to the horizon. One weight rests on the plane; the other hangs freely. If W_1 draws up W_2 in just half the time that is required for W_2 to draw up W_1, find how the weights compare.

6. A juggler keeps 3 balls going with one hand so that, at each instant, 2 balls are in the air and 1 is in his hand. Find a relation between the height to which a ball must rise and the time each one stays in his hand.

Mail your answers to the Editor of the Section, Professor Miller.

THE COLUMBIA BASIN PROJECT

OTIS W. FREEMAN, KATHERINE BURGESS, EDITH CAMPBELL AND BARBARA DEFFERT*

Eastern Washington College of Education, Cheney, Washington

HISTORY

Since before the dawn of history the Columbia River, unmolested by man, has been flowing to the sea. Exceeded in volume of flow only by the Mississippi River in the United States. and possessing more available power than any other river system in North America, the Columbia has constituted one of the greatest unused resources in the world.

Settlers early mentioned the desirability of irrigation in the arid region east of the Columbia River in central Washington, and surveys were undertaken under both government and state auspices but no construction was begun until 1933. In 1903 the United States Bureau of Reclamation made a survey of the Columbia Basin to determine the feasibility of diverting water from the Spokane River, or the Pend Oreille River, but this was found impracticable. In 1909 a project to bring water from the Wenatchee River was submitted to the voters of the state who rejected the required $40,000,000 bond issue. The plan was studied by the U. S. Bureau of Reclamation but was deemed too costly for the amount of land susceptible to irrigation. In 1918 a new proposal was made to carry water from the Pend Oreille River by another route with a storage reservoir at Rock Lake about 30 miles south of Spokane.

Several men early suggested the construction of a dam across the Columbia River near the head of the Grand Coulee that would supply water for both power and irrigation. The Bureau of Reclamation considered this source in their 1918 report. In 1921 the U. S. Army engineers made preliminary surveys and declared the plan feasible. In 1932 the Bureau of Reclamation concurred regarding its feasibility. In July 1933 President Franklin D. Roosevelt designated the Grand Coulee Dam as a Public Works Project and allocated $63,000,000 for the purpose. The original plan was for the construction of a "low dam" for power only. But in 1935, when the "Grand Coulee Project on the Columbia River" was duly authorized by Congress, the height of the dam was increased to make the structure serve the dual purpose of power and irrigation in the Columbia Basin.

The U. S. Bureau of Reclamation was in charge of construction.

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* This paper was prepared with the cooperation and under the direction of Professor Otis W. Freeman by the three students listed as co-authors, who were enrolled in the Columbia Basin Workshop held during the summer of 1947 at Eastern Washington College of Education, Cheney, Washington.

Contracts were let and the pouring of concrete began November 6, 1935. Pouring continued day and night for the next three years, until the 11,250,000 cubic yards of concrete, required for the structure,

had been placed. To accomplish this over 3,000,000 bucket loads of concrete were dumped.

Two power houses were constructed. The first turbine-generator was installed in 1941. In 1947 six large generators, each of 108,000 kilowatts (144,000 horse power) capacity, were in service and three others under construction. These will complete the installations in the west side power house. Three generators will be installed next in the east side power house. Six others will follow as soon as authorized by Congress. The plans call for 18 generators with a total output of 2,600,000 horse power (1,944,000 kilowatts).

The Dam

The Grand Coulee Dam across the Columbia River is the most colossal structure of its kind ever built. It is 4,300 feet long on the crest, 550 feet high above lowest bedrock, and 500 feet thick at the base, tapering to 30 feet at the top. The dam contains over three times the masonry in Hoover Dam, formerly called Boulder Dam, a higher but shorter structure. The spillway is over twice as high as Niagara Falls, and during floods the volume of water exceeds that of the Niagara River.

Before building the dam, over 20,000,000 cubic yards of gravel, clay, and boulders had to be removed down to the solid granite of the canyon walls and bed of the Columbia. In order to accomplish this excavation a coffer dam, 2,900 feet long, 50 feet wide and 110 feet high above bedrock, was constructed on the west side of the river which here flows northward. A conveyer belt 60 inches wide was used to transport the excavated material. It handled 60,000 cubic yards per day, carrying a "river of dirt" one and one-third miles, up 450 feet, into Rattlesnake Canyon. The last excavation in the bed of the river was finished in the spring of 1937. After the foundations of the dam had been laid in the cleared streambed, the river was shifted by means of other coffer dams, and made to flow through slots in the dam left for the purpose until the rest of the debris had been removed from the valley floor.

Very favorable features for dam construction at the selected site included (1) a firm, impervious bedrock foundation of solid granite, (2) suitable dumping ground for many millions of cubic yards of debris, (3) a natural supply of both coarse gravel and fine sand high on the east bank that was ideal for making concrete when washed and mixed in proper proportions. At first, gravel and sand were carried across the river on a conveyor belt to a mixing plant on the west side that supplemented one on the east side. Later, the concrete was all mixed on the east side and a high trestle was built to deliver it by

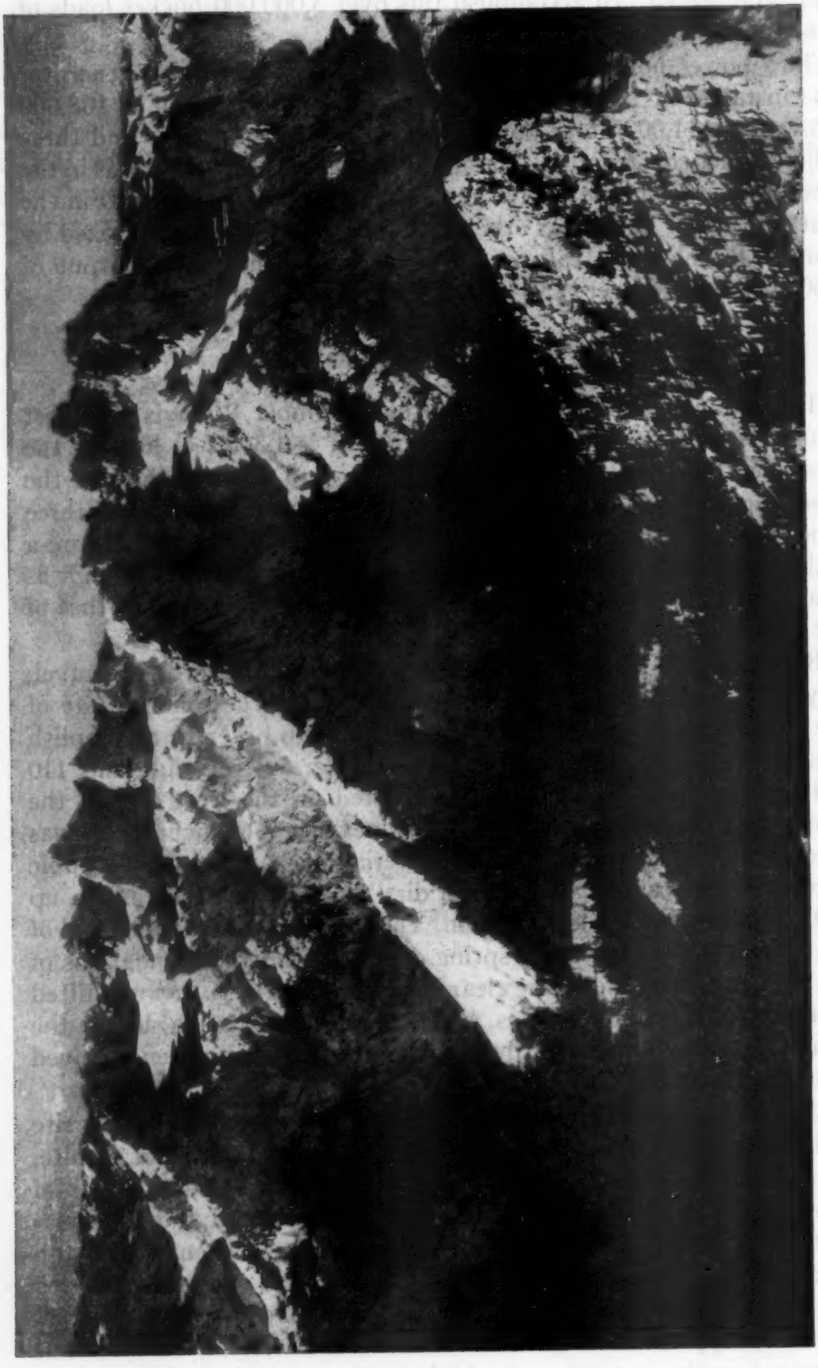

FIG. 1. Drainage into the Columbia River largely comes from rugged mountains, snow capped much of the year.

means of buckets, at the rate of 10,000 to 15,000 cubic yards each 24 hours.

The dam was built in sections 50 feet square and five feet deep. After being filled with concrete the lift forms were raised and the process repeated. As the structure of the dam grew, the high trestle was buried forever under concrete. Hundreds of miles of pipe containing circulating water were installed in the dam to cool the concrete. Otherwise it would have required several centuries to cool naturally from the heat generated by the setting of the concrete. Natural cooling might allow contraction cracks to develop that would weaken the structure.

Special problems included: (1) control and diversion of the second largest river in the country which may rise over 50 feet during floods and which in 1894, carried 725,000 cubic feet of water per second; (2) trouble with loose debris and wet clay sliding into the excavation controlled on the west bank by drainage and removal of extra material, and on the east bank by artificially freezing the ground to form a temporary dam against slides; (3) the enormous quantity of material, over 15,000,000 cubic yards, that required removal to reach bedrock and the enormous mass of concrete to build a dam of over 2½ times the volume of Hoover Dam; (4) construction of four great coffer dams, one on each side of the river and two across the river itself to permit excavation of dirt and pouring of concrete.

In the summer of 1933 one ferryman lived with his family at the dam site. Two years later 15,000 people resided within the same area. Of these 3,000 were in Mason City, the contractors' town; 1,000 in Coulee Dam, the reclamation engineers' town; the rest in several privately developed townsites. A maximum of 6,600 men was employed by the first contractors, the Mason-Walsh-Atkinson-Kier Company. They were used for the excavation and diversion of the river as well as the pouring of concrete. Later contracts for concrete pouring only, went to the Consolidated Builders, Inc. This concern employed about 3,000 workmen.

The cost of the Grand Coulee Dam and power plant has been around $130,000,000. Additional sums will be expended for the installation of more generators. The cost of reclaiming 1,200,000 acres of land will total about $200,000,000 more. The total expenditures for the Columbia Basin Project were estimated at $394,000,000. At present prices this amount will likely be exceeded. However, since revenues from the sale of power should pay for the dam and power plant in about forty years in addition to half the cost of reclamation, government engineers estimate that the government will invest not over $260,000,000 all of which should ultimately be paid back.

Power

The Pacific Northwest (Oregon, Washington, Idaho and western Montana) with 12 percent of the area of the United States and less than 3 percent of the population has by far the greater share of potential hydro-electric power. Washington state alone, controls 41 percent of the nation's potential water power, 75 percent of which is vested in the Columbia River. This river rises in the Canadian Rockies. Fig. 1. It breaks through the ramparts of the Rockies and tumbles southward across Washington state, falling 1000 feet in 400 miles. It is the region's most valuable asset. It is inexhaustible, unlike the minerals, forests and rapidly eroding soils.

Many excellent dam sites occur along the mighty Columbia. Three sites have been developed and are furnishing hydro-electric power. Bonneville and Grand Coulee dams were built by the Federal Government and Rock Island near Wenatchee by private capital. Work has commenced on the McNary Dam near Umatilla, Oregon, and plans have been made for the development of Foster Creek below Grand Coulee Dam, Priest Rapids below the Rock Island structure, and the Cascades at the Dalles, Oregon. Rapidly expanding demands for power in the region will lead to the construction of hydro-electric plants at these and other available sites.

The Grand Coulee Dam (Fig. 2) impounds Lake Roosevelt, 151 miles long, reaching to the Canadian border. The height of the dam was limited by the fact that the water level must not encroach upon foreign territory. The flow of the Columbia is so great that the level of Lake Roosevelt will not be lowered by requirements of water for power and irrigation. This permits the use of the long and attractive shore line of the lake for recreation. The effective head of water at Grand Coulee Dam is about 300 feet. From Lake Roosevelt irrigation water will be lifted 270 feet into a balancing reservoir 27 miles long impounded by two earth and rock dams at the head and foot of the upper Grand Coulee.

The completed structure includes two separate, but similar power houses, one on either side of the river, each to contain when completed 9 generators of 108,000 kilowatts (144,000 horse power). The power houses are separated by a spillway section 1,650 feet long over which flows the water not required for storage, irrigation, or power generation. The rate of the flow and to a certain extent, the quantity of water held back in storage, is controlled by 11 drum gates at the crest of the spillway, each gate being 28 feet high and 135 feet long.

At the base of the spillway is an upward-curved bucket 100 feet wide and 30 feet deep behind a concrete wall across the river to prevent erosion of the river below the dam. Through the dam there are 60 outlet tunnels with 8½ foot gates: 20 at low-water level, 20 at

1,034 feet elevation, and 20 at 1,134 feet elevation, for the purpose of controlling the water level behind the dam. Steel trash racks protect the intake openings. These outlet tunnels have a capacity of 253,000 second-feet; the turbines, fully loaded, will pass 81,000 second-feet. These, with the spillway, have a total capacity nearly 3 times the maximum recorded flow of the river and nearly double the estimated flow of the river in the flood of 1894. Eight miles of inspection corridors

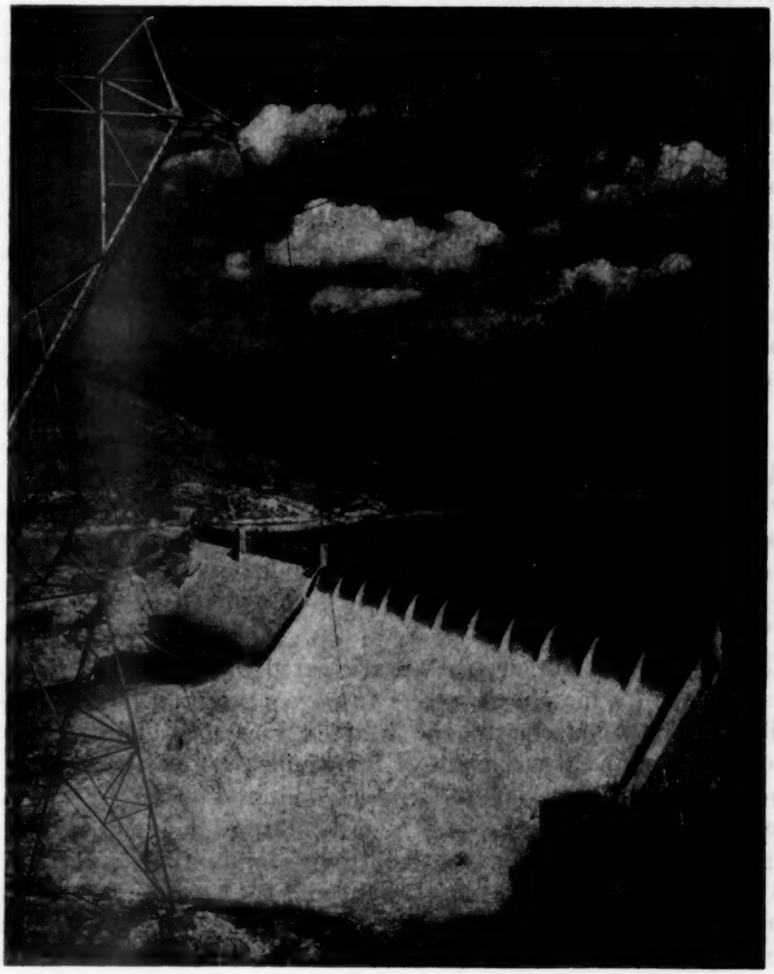

FIG. 2. The Grand Coulee Dam showing the West Side Power House on the right which at present furnishes all the power output, and the East Side Power House on the left in which installation of generators will soon begin. Lake Roosevelt above the dam extends 151 miles to the Canadian boundary. (Photo by U. S. Bureau of Reclamation)

connect the several sections of the dam. Automatic elevators carry men and equipment from one level to another.

The Grand Coulee Dam is a multiple-purpose dam. While its primary purpose is irrigation, it will affect navigation, influence flood control, and be the source of the greatest production of power in the world. Because power was greatly in demand and could be developed at an early stage of construction the power houses were rushed to completion as soon as possible. The receipts from the sale of power have helped to pay for the entire project.

The first commercial delivery of power from Grand Coulee Dam was made on March 22, 1941. Two 10,000-kilowatt generating units, designed to carry only local loads, were connected to the 234-mile transmission lines joining Grand Coulee and Bonneville Dams, to help fill the pressing demand for electricity in the production of aluminum. On the first of October, 1941, the first of the large generating units to be completed replaced the above smaller units.

Shortly after war was declared a second large generator was ready for service, and on April 7, 1942, the third began supplying power to war industries in the Pacific Northwest. Early in 1943 two borrowed 75,000 kilowatt generating sets, built for use at the uncompleted Shasta Dam in northern California, were carrying wartime overloads in the power plant at Grand Coulee. Later the same year the number of large units was increased to five. The sixth of the large generators added its output to the wartime supply of power on February 11, 1944. The borrowed generators have now been shipped to Shasta Dam. They more than paid for the expenses of installation and dismantling by their production of power while in operation.

Marketing the Power

Three Government agencies participated in the war power program in the Pacific Northwest—two power producers and one distributor. The producers were the Army Engineers, who built and operated the dam and power plant at Bonneville near Portland, Oregon, and the Bureau of Reclamation, which built and operated the Grand Coulee Dam and power plant. The distributor of power from the two great Government power plants on the Columbia River is the Bonneville Power Administration. It built and operates the Government power transmission system which interconnects the Government power plants with each other and with the load centers near Spokane, Portland, Seattle, and Tacoma. It is the largest wholesaler of power in the Pacific Northwest.

Early in the war to utilize to the fullest extent the power facilities in the Pacific Northwest, and to make their services more reliable, all the power systems, public and private, in Washington, Oregon,

western Montana, and northern Idaho were interconnected to form the Northwest Power Pool. When operating separately, each system had idle equipment, and each was dependent for its output on the stream flow and water storage facilities in its own territory. Each had been designed to serve ordinary domestic municipal purposes, and industries operating on a peacetime basis. The needs of war industries increased greatly the demands of power, and lengthened the working day—in some industries to 24 hours.

Through the Northwest Power Pool surplus power in one area can be made available in some other area where there is a deficiency, either because of water shortage or because of heavy demands for power. Interchange of power also reduced the amount of steam power used during the war, and saved large quantities of critical fuel oil and coal. The Government-owned power plants and high-voltage transmission systems constitute a "backbone" for the huge interconnected system. The plant at Grand Coulee Dam is by far the largest unit. It is well situated, near the center of the system, and can send its power wherever it is needed. During the war the plant at Grand Coulee was the only one in the pool with sufficient water available to run it full time, throughout the year, with a full load.

A large part of the output of the Government plants at Grand Coulee and Bonneville went directly into war work, especially into the production of light metals and the rolling of aluminum. Power for the atom-smashing plant of the Hanford Engineer Works was supplied from the power plant at Grand Coulee Dam. However, much of the output was supplied to municipal and private power systems, where it was distributed to shipyards, airplane plants, tank factories, machine shops, and to hundreds of shops and factories, large and small, engaged in producing war material.

Now that the war is over, the large power facilities at Grand Coulee can be turned to the constructive work of peace. They will supply water for irrigating more than a million acres of potentially irrigable land in the Columbia Basin. They will furnish power for household labor-saving equipment and machinery on farmsteads and in food processing plants. The abundance of cheap power will attract factories and industry to the Northwest. All this will work directly for the benefit of the people.

The demand for power at present exceeds the supply available. With increasing demands for power, as development of the Columbia Basin proceeds, the remaining generators will be installed as fast as possible. Three are now under construction. The plan to develop all the potential power of the Columbia River and its tributaries by building more dams at strategic points ultimately will develop 92 percent of the potential power in the river.

FIG. 3. The Bacon Tunnel that will carry the flow of the main canal. (Photo by U. S. Bureau of Reclamation)

The full development of potential power in the Northwest will help in utilization of the great mineral resources in the region. Within this area are deposits of dolomite (an ore of magnesium), limestone, magnesite, aluminum, clays and phosphate rock all of which are raw materials for electro-chemical and metallurgical plants that require large blocks of power.

Irrigation

The Environment

The surface features of central Washington, determined by geology, markedly affect the development of the Columbia Basin Project. The region lies between the Cascade and Rocky Mountains and is a part of the Columbia Intermontane Province whose bedrock is predominantly dark colored basaltic lava. Towards the margins of the area the flows of lava covered the lower slopes of the adjacent mountains composed of hard rock resistant to erosion. Such rock is often exposed in the bottom of deep canyons, for example at Grand Coulee Dam. The outpourings of lava doubtless originally formed a plain which was later warped both upward and downward. Two of the downwarps formed the Quincy and Pasco Basins that contain most of the land that will be irrigated. These two depressed areas form the central plains area of the Columbia Basin and are partly separated by the sharp unfold of the Saddle Mountains and Frenchman Hills entering the region from the west. The Columbia Basin rises in all directions from the central plains. The Waterville Plateau at the northwest corner is trenched by the canyons of the Columbia River and the Grand Coulee. To the east are the Palouse Hills, highly productive for wheat raised by "dry farming" methods. Here rainfall is more favorable than in the Quincy and Pasco desert areas. South are the barriers of the Blue Mountains and Horse Heaven Hills and southwest the elongated folded hills of the Yakima region.

In the Glacial Period lobes of ice from Canada invaded the northern portion of the Columbia Basin. The Columbia River was blocked by a glacier and the glacial melt water was forced to seek new courses downslope across eastern Washington towards the Snake and Columbia rivers. Erosion by the torrents of melt water removed the surface soil down to the lava bedrock over extensive areas. The bare lava was called "scabrock" by early settlers. The whole system of intertwining channels of scabrock through which the glacial flood waters poured has been named the Channeled Scablands.

The most spectacular channel is the Grand Coulee. The channels are often followed by railroads and highways and some will be utilized for storage reservoirs and the site of distributing canals for irrigation

of the Columbia Basin. Much of the debris from the melting glaciers and that washed from the Scabland channels was deposited in the Quincy and Pasco basins. Some of the deposits are so stony that they will be unsuited for irrigated farming. But much of the plains and slopes are covered with fertile silt that is very productive when irrigated. Most of the land can be supplied with water by gravity from the balancing reservoir to be located in the upper Grand Coulee.

At present only a little irrigation is practiced in the Columbia Basin because; (1) most of the area lies several hundred feet above the Columbia River and pumping is too expensive for extensive use, (2) local surface water supplies are very limited and (3) ground water levels are too deep for economical pumping. But where water is available the Columbia Basin enjoys a long growing season, 150 to over 200 frost free days. This long growing season in combination with abundant sunshine, makes possible the production of a variety of crops.

Water Distribution

The Columbia Basin Irrigation Project will reclaim over one million acres in Grant, Adams, Franklin, and Walla Walla Counties, an area about 60 miles from east to west, and about 80 miles from north to south. It will be served by the largest pumping plant yet devised. This plant is being built behind a "wing dam" beside the Grand Coulee Dam. It could supply the 140,000,000 people in the United States with all the domestic water they would normally use. Short tunnels tapering from 23 feet to 18½ feet in diameter will carry steel outlet pipes from the pumps to the headworks of a feeder canal, 1.6 miles long. This canal will be 25 feet deep, 125 feet wide at the top, and 50 feet wide at the bottom, largest in cross section of any in the irrigation system, and will discharge into the Equalizing Reservoir.

The Equalizing Reservoir, covering most of the floor of the upper Grand Coulee, will be 27 miles long, and from 1½ to 5 miles wide, with an active storage capacity of 700,000 acre-feet. The North Coulee Dam, about ½ mile down the Grand Coulee from the town of Grand Coulee, will form the northern end of the Equalizing Reservoir. It will stretch across the Grand Coulee for approximately 1,400 feet, and will be 115 feet high above the lowest foundation rock. At the southern end of the Equalizing Reservoir, the South Dam, of earth-fill construction, 10,000 feet long, 65 feet high, with a maximum width of 450 feet at the base, and a roadway 42 feet wide on the top, will extend in a western direction from the outskirts of Coulee City. These dams are built above a five-foot concrete core wall. The central, impervious portion consists of an embankment of selected clay, sand,

and gravel, applied in six-inch layers, and compacted with sheepsfoot rollers. The portion of the embankment on either side of this section will be gravel, with an outside facing of rock, to combat any possible erosive action by water.

Leading from the South Dam, in the vicinity of Coulee City, will be the project's main Canal, which will be capable of handling sufficient water for a million acres of farm land. Its length, including the Bacon Siphon, Bacon Tunnel, Trail Lake, and Long Lake sections, will be about 20 miles. It will carry irrigation water south to the headworks of the East Low Canal and the West Canal near Adrian. The northern section of the Main Canal—that part above Long Lake—will be 7.7 miles in length, including the siphon, tunnel, and Trail Lake, and will end on the rimrock above Long Lake Coulee, where canal water will plunge 165 feet into Long Lake. Future plans provide for a power plant here. The East High Canal will take off just above the falls. A highway and a railroad bridge will be constructed across the Trail Lake section of the canal.

About two miles south of Coulee City, a deep coulee cuts across the Main Canal. Irrigation water will cross this coulee in the Bacon Siphon, a circular tube of reinforced concrete, 1,000 feet long. After crossing the Coulee, the Bacon Siphon will end in the Bacon Tunnel, (Fig. 3) about half way up the south wall of the Coulee, extending nearly two miles through a lava ridge, and emerging in Trail Lake.

From the south end of Long Lake, which will be raised 90 feet and lengthened to 5½ miles by an earth dam, the water supply will be carried through the Main Canal 6.6 miles to the bifurcation works, located 2½ miles north of Adrian, at the heads of the East Low Canal and the West Canal.

The West Canal will be 88 miles long, and will serve 281,000 acres in the western part of the Columbia Basin Project. It will be built near the northern and western boundaries of the project for about 50 miles, passing close to the towns of Soap Lake, Ephrata, and Quincy. A 9,150-foot tunnel will carry it through the Frenchman Hills to the Royal Slope, where it will branch to the east and west. The siphons, known as Dry Coulee Siphons 1 and 2, will be the largest in the Pacific Northwest. The Soap Lake Siphon, will carry the irrigation waters across the lower Grand Coulee, north of Soap Lake, and will be about 12,000 feet long and 23 feet in diameter.

The East Low Canal will be 130 miles long, and will carry sufficient water to irrigate 252,000 acres. From the bifurcation works, six miles east of Soap Lake, this canal will extend southeast length of the project, terminating in the Snake River Valley. The Potholes Dam, (Fig. 4) 12 miles south of Moses Lake, near the center of the Columbia Basin Project, will be the largest of 4 earth-fill dams and fourth

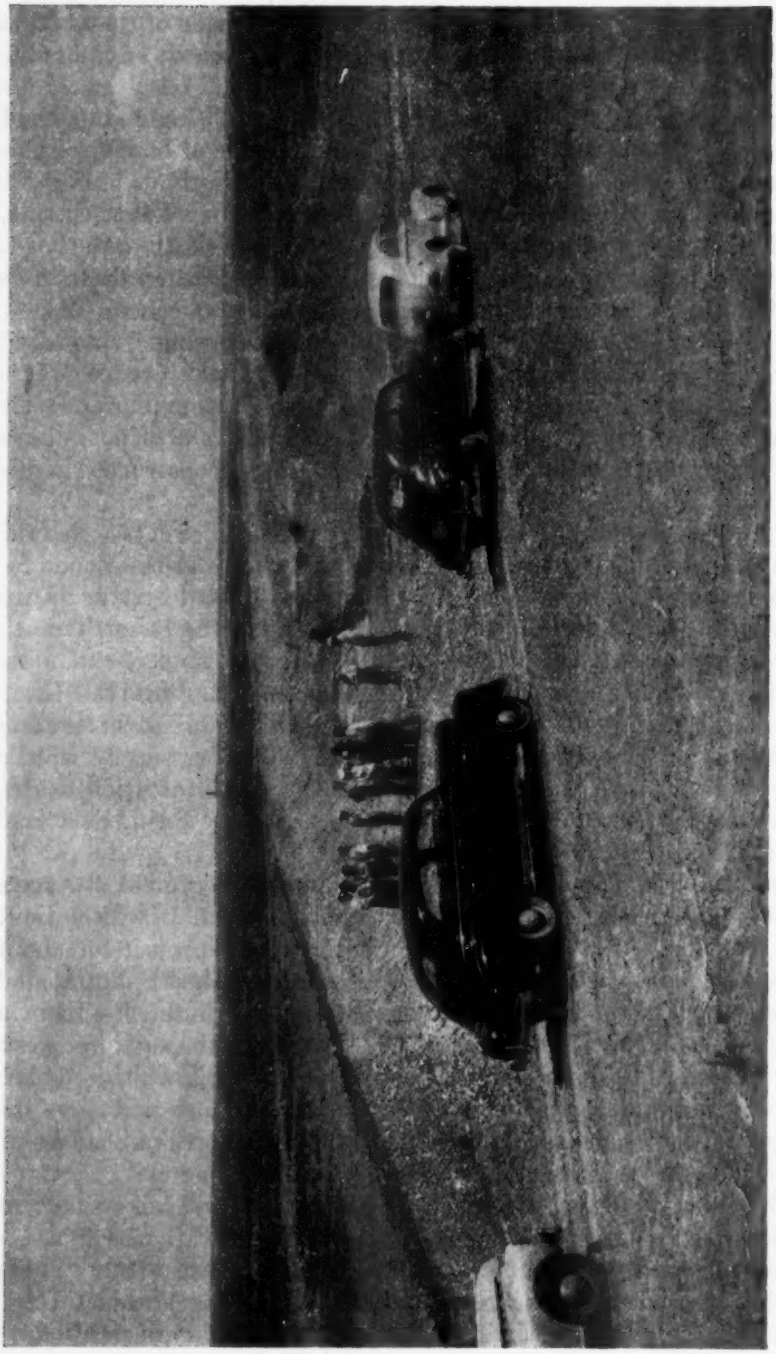

FIG. 4. The Potholes Dam at an early stage in the construction. The piles of dirt show the width of the dam at its base.

longest dam in the United States. It will extend 3½ miles in an irregular east-west course, and will have a maximum height of 207 feet above bedrock. Its volume—9,190,000 cubic yards—will be nearly as great as that of the Grand Coulee Dam. A public road will cross the top of the dam. The Crab Creek Channel, and other natural channels, at the east end of the Frenchman Hills, will be closed. The reservoir created will cover 47 square miles and will have nearly 250 miles of shoreline. It will raise the level of Moses Lake 5 or 6 feet above its normal level. It will store water draining from lands in the northern part of the project, for re-use on approximately 270,000 acres in the southwestern part.

The Potholes East Canal will extend from the reservoir south and east almost to Pasco, and will serve 254,000 acres. A branch will extend west to irrigate the Wahluke Slope, on the south side of the Saddle Mountains. The Potholes West Canal will serve 13,600 acres along the base of the Royal Slope, on the south side of the Frenchman Hills.

A pumping plant and lateral system about 12 miles northwest of Pasco is nearing completion. This will pump water directly from the Columbia River. It is being constructed since it will take considerable time to extend the main distribution system to this area. Water should be available on the land by the fall of 1947. When this area is served by the Potholes East Canal, the pumping plant will be salvaged. Another pumping plant, on the south bank of the Snake River a few miles east of Pasco, will serve the Burbank unit.

Land to be Irrigated

During the survey period the Bureau of Reclamation tested and appraised all lands in the Columbia Basin Project as to their suitability for farming. Fig. 5. Three general classes of arable land were designated as follows: Class 1 has deep loamy soil, with not more than 5% slope, and is well suited to the production of row crops, such as potatoes, sugar beets, and truck crops, as well as hay and pasture. Class 2 has slightly less fertile soil with up to 10% slope. Class 3 has inferior land, suitable mainly for hay and pasturage. Farm units irregular in shape, and including the several classes of land, have been laid out by the Bureau of Reclamation. The maximum price of land is based on its present dry-land value. Lands suited principally for grazing were valued within the following ranges: Class 1—$7.50 to $10.00 per acre; Class 2—$5.00 to $7.00 per acre; and Class 3—$2.50 to $4.50. Lands adapted to dry farming were found to have higher values, ranging in some cases up to $30 per acre.

Settlers who owned land within the districts before May 27, 1937, will be allowed to retain any 160 acres of their holding which they

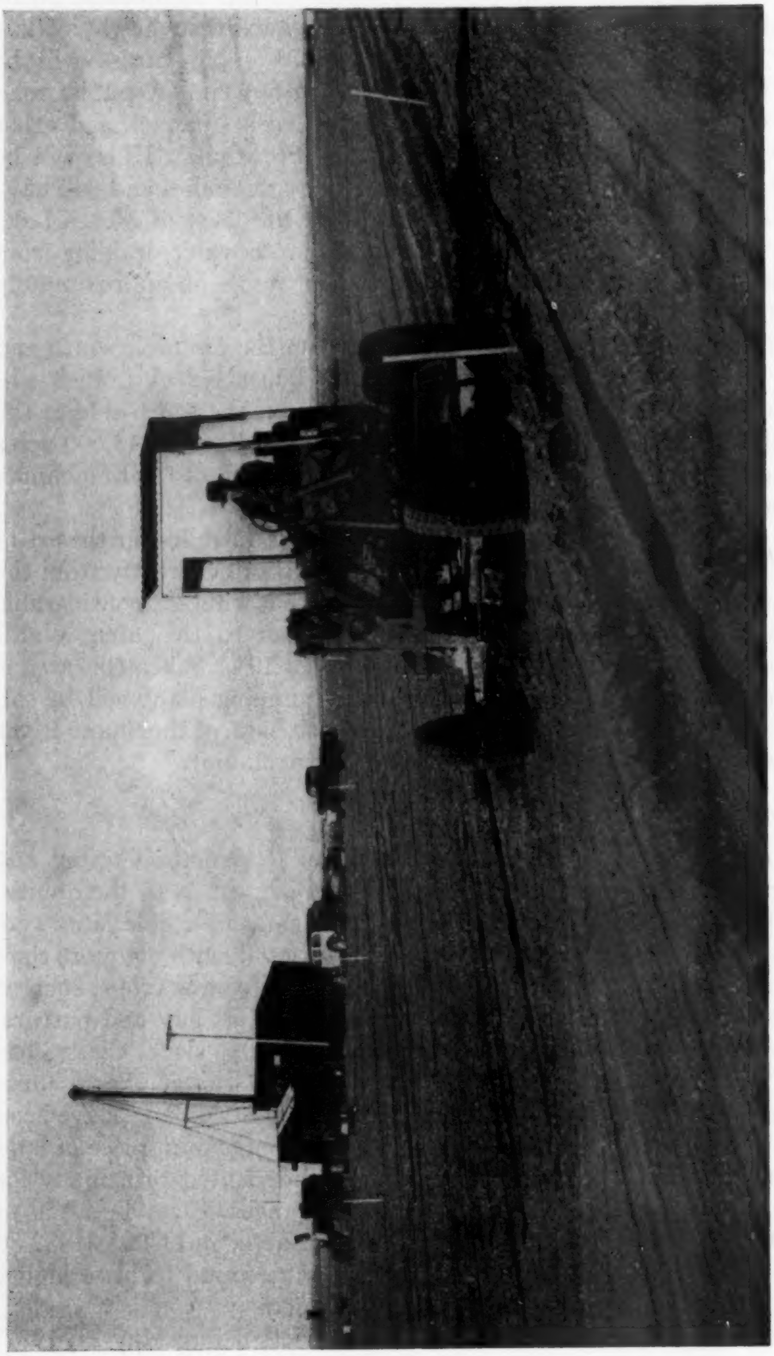

FIG. 5. Preparing an experimental farm in the Columbia Basin.

wish to be eligible for water delivery. They may also withdraw any land owned by them up to a certain date. Such land will not be eligible for water delivery unless first sold to the government. Newcomers will not be permitted to purchase land in excess of a total of 160 acres.

The water allotment per acre will be 2 to 4 acre-feet annually. Construction and irrigation costs are expected to average $85.00 per acre. The annual charge for irrigation water has not yet been fixed. No re-payment costs will be charged during the development period which will be approximately 10 years. A 40-year period without interest will be allowed to repay construction costs. Maintenance and operation charges will average around $21.60 per acre annually. Experience shows that the prospective settler should have from $7,000 to $10,000, or the equivalent in equipment and livestock, to develop the average farm. This outlay, however, need not be made as soon as the farm is settled. In most cases, full development costs are not incurred until 10 or 15 years after settlement.

Future

For every one who lives in the area developed, two other persons will be needed in service occupations, to handle the products and manage the businesses which this vast development will bring. This increase in population will help furnish markets for the agricultural produce of the reclaimed lands, the development of truck and fruit farms to supply local demands and to furnish fruit and vegetables to processing plants may be expected. Extensive crops such as cereals and alfalfa will be accompanied by live stock including, beef, cattle, hogs, dairy cattle, and sheep. There will also be greater demand for manufactures made from the raw materials of the Pacific Northwest such as coal, clay, phosphate rock, and timber. With the cheap power available, new industries, such as chemical and metallurgical plants, utilizing electrical processes, will be established.

Planned Community Life

Highways and schools will be developed by the State. Consolidation of school districts with adequate transportation facilities will provide the best in educational opportunities. Parks and recreational areas will be established or enlarged and the outstanding areas developed and improved to attract visitors from distant places. An example of such development is Dry Falls State Park where overnight accommodations, a golf course, fishing, boating, and swimming facilities have been established, and a large hotel planned.

Lake Roosevelt, brings an extensive new recreational area into existence. It connects with the Arrow Lakes in British Columbia and

furnishes a 300 mile water-course through ideal scenic country. Unlike most reservoirs used for supply of irrigation water, Lake Roosevelt will have a constant level without unsightly mud banks caused by the drawdown of water during the irrigation season. The uniform level is made possible by the large flow of the Columbia River that greatly exceeds the requirement for irrigation.

The Bureau of Reclamation, with existing agencies, will cooperate in the development of community centers where domestic water, light, transportation facilities, churches, stores, theaters, auditoriums, parks, and social centers, will serve the surrounding areas. They will thus seek to avoid useless and expensive duplications. The farmer will have all the conveniences and comforts of modern living. The hardships of pioneer life will be conspicuously absent. In a planned development many of the mistakes of boom towns, with their attendant misery and squalor, and the difficulties which follow speculation and wild-cat schemes will be eliminated.

The Columbia Basin Project will furnish farming opportunities for many, and attract skilled workers to its manufacturing and commercial centers. It will make an outstanding contribution to the future destiny of the Pacific Northwest.

NEW SCIENCE ADVENTURES SLIDEFILMS—*THE SKY*

A new kit of seven discussional slidefilms, *The Sky*, is announced by The Jam Handy Organization. The material for these films has been prepared for later elementary and junior high school science classes in the study of the sky. The films are designed to help the teacher cover more material in less time and with greater student understanding. Inasmuch as visual aids are a "must" in teaching this subject, the kit is of particular value to the science teacher. Flexibility in use has been one of the guiding principles in preparing these films. The complete films or lessons may be used independently as the teacher desires.

Film titles in the kit are: 1. A Multitude of Suns. 2. Stories of the Constellations. 3. The Sun's Family. 4. Interesting Things about the Planets. 5. Our Neighbor, the Moon. 6. The Changing Moon. 7. How We Learn about the Sky. For details, write to The Jam Handy Organization, 2821 East Grand Boulevard, Detroit 11, Michigan.

BIGGEST EDUCATIONAL JOB

An estimated 32 million young education-seeking Americans, including more than a million veterans, will jam our schools and colleges this fall as the nation undertakes the biggest job in the history of democratic education, according to the US Office of Education. John W. Studebaker, US Commissioner of Education, emphasizes that the biggest problem facing American education is still a serious shortage of qualified teachers: "We will need about one million new teachers in the next ten years and about 350,000 new classrooms."

MODERN TRENDS IN MATHEMATICS EDUCATION*

W. D. Reeve
Teachers College, Columbia University

It is most interesting and also instructive to note that it took a World War to make the American people realize that basic mathematical instruction in the schools of this country was woefully deficient. When Admiral W. O. Nimitz wrote the now famous letter[1] to Louis J. Brevold criticizing severly the inadequate preparation in arithmetic of the Navy recruits that had then come to his attention, he started something that even he probably did not expect to happen. Of course one would naturally question whether the mere fact that such recruits showed inadequate facility in common arithmetical operations was any *prima facia* evidence that these boys had not received careful instruction in the elementary school. Adults who may have been very well taught in their youth by competent teachers may by disuse forget many of the skills that they may have previously established to a satisfactory degree of mastery.

It is only natural then that some people have questioned the validity of the Navy tests for judging the degree of mastery of skills previously taught to pupils in the schools unless perhaps, as has been done in some similar situations, simple and brief review procedures were adopted for the purpose of improving the recall of certain items of skill. On the other hand, you and I know that in general and in many particular instances, there is a large element of truth in the criticisms hurled at the schools by Admiral Nimitz. In fact, such criticisms have been made before by various leaders in the educational field, but the deficiencies thus disclosed did not seem to be so tragic at the time because the public was not made so conscious of the possible dire results of such a sad state of affairs. Knowledge of arithmetic in particular and of mathematics in a broader sense was not necessary to protect our freedom, or at least we did not realize that it was necessary, and so nothing much was done about it.

What you and I should insist upon in the future is the fact that initial learning which is not accompanied by a sense of pleasure in the process resulting in real understanding is not enough at any time war or no war. Moreover, interest in and enjoyment of learning followed by complete mastery in the early years of one's active experience is never enough. No doubt many of the Navy recruits whom Admiral Nimitz tested as well as thousands of other American boys and girls learned many of the important arithmetical skills more or less by

* Paper read at the Institute of Teachers of Mathematics at Duke University, Durham, North Carolina, on Saturday, August 9, 1947.

[1] See *The Mathematics Teacher*, Vol. 34, February 1942, p. 88.

memoriter methods. The same thing is still going on in the schools even in algebra, and geometry. Very little thinking is going on in the minds of entirely too many pupils in the schools.

In attempting to find out how seriously we should take the criticisms of Admiral Nimitz and others, Brueckner conducted a National Survey, the complete results of which have been reported elsewhere.[2]

The schools throughout the country are now confronted with the problem of deciding what they can do to improve the mathematical abilities of those pupils and others in the community who are almost certain to need mathematics in their life work. It is only fair to say that some teachers are taking the situation seriously, while others, if not completely apathetic about it, are doing little or nothing constructive so far as one can observe from the outside.

Let us now consider what should be done all along the line to improve the mathematical background of our people so that in peace times as well as in war time they can function as intelligent citizens whether or not a definite crisis exists.

According to Studebaker[3] we need to make little change in elementary school education. He said:

> My first suggestion concerns the elementary schools. Perhaps less than at any other level of education, does winning the war imply conversion in the curriculum of the elementary school. The fundamentals of childhood education, with their emphasis upon mental security, physical health and growth, and command of the tools of learning are not altered for the emergency. Moreover, millions of elementary school children will still be in school when victory is won. They must grow up to help in the long slow task of rebuilding the post-war world, of healing its rancors, of binding up its wounds, of creating that spirit of brotherhood which alone enables men to live at peace with their fellows. The special contributions which elementary schools can make to winning this war are therefore expansions of the kinds of tasks which they are already accomplishing: the care and protection of young children in nursery schools and kindergarten, the provision of before and after school programs of recreation for children of working mothers in congested war service areas; the expansion of school facilities and services to include nutritious school lunches; closer cooperation with parents in safeguarding children's health and morals.

While the preceding quotation may represent the general situation adequately, there still seems to be some need for improving arithmetical instruction in the elementary school in order to make sure that here, at least, the proper mastery of the fundamental skills must be attained and their permanence left to the teachers in the high school grades. Arithmetic is a sequential subject, and of all the subjects in the elementary school it is the one that cannot be left to some kind of incidental treatment. As we shall see later, arithmetical skills must

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[2] Brueckner, Leo J., "Testing Validity of Criticisms of Schools," *Journal of Educational Research*, Vol. 1943, pp. 465–468. See also Brueckner, Leo J., "Mathematics to Serve War Needs," *The Journal of the National Education Association*, Vol. 32, October 1943, p. 203.

[3] Studebaker, John W., "What the Schools and Colleges Can Do to Help Win this War." General Session, National Institute on Education and the War. American University, Washington, D. C., August 31, 1942.

be maintained throughout the secondary school period, but first of all a satisfactory attainment of these skills must be made in the elementary schools.

If mastery and maintenance of arithmetical skills is a legitimate goal of the schools, then we must have more practical application of these skills in realistic situations all along the line. By this I do not mean to go off on any tangent and introduce the *project method* or any of the time honored methods of dodging the real labor involved in mastering arithmetic. I mean that arithmetic should be taught with meaning and insight.

We would also do well to consider further certain omissions and additions in elementary arithmetic which I have previously discussed elsewhere.[4] In arithmetic we should omit the following:

1. Much of the work in common fractions is of no practical use any longer and is discouraging, meaningless, and unnecessarily difficult for children. In many cases difficulties can be avoided by replacing the common fraction by a decimal, as in the formula $F=1.8c+32$. David Eugene Smith once said, "Meeting a common fraction is like meeting a ghost at night. Turn on the light and the light is a decimal fraction."
2. A great deal of the work with decimals, including addition and subtraction of "ragged decimals," and the useless cases in multiplication and division which still persist.
3. Such parts of work in denominate numbers as are no longer used, certainly not more than two denominations as in 2 ft. 5 in. Some advance is already being made in this direction.
4. Square and cube roots except by the use of tables. The theory belongs in algebra, if anywhere.
5. Such extended computations as have no applications within the child's range of knowledge. This includes difficult and discouraging work in the mechanics of multiplication and division, which operations are now practically done by calculating machines when met with in actuarial work or in physics and astronomy.

This suggestion of elimination does not mean the lessening of time allowed to the subject. On the contrary it means the replacing of the useless material by that which belongs to the twentieth century instead of the seventeenth. The nature of this new material will possibly require even more time, although this will probably be unnecessary for the average pupil who does not stand in need of the arithmetic of special fields of commerce, industry, and other technical lines. This does not mean that material should be omitted solely

[4] Reeve, W. D., "A Proposal for Mathematics Education in the Secondary School of the United States." *The Mathematics Teacher*, Vol. 36, January 1943, pp. 11–20. See also Reeve, W. D., "Mathematics for the War Effort." *Teachers College Record*, Vol. 44, February 1943, pp. 327–335.

because of its age, but age alone should not settle the question.

In arithmetic we should add the following:

1. The story of our numerals, not to learn but to enjoy; not extensive but as it is related to the growth of knowledge.
2. Number games as a reward, not as a task.
3. Applications to school and home life, with problems actually brought in by the class.
4. Similarly, applications to the social and civic life of the class. These are easily used to advantage as soon as the elimination of useless material allows time for the real problems of home life (cooking, cost of gas or electricity, cost of heat, and the like), games, and what in general may be called "the arithmetic of environment." Considerable progress has been made in this field, but much more can be made if we save time as suggested.
5. The use of simple algebra such as that from Grade VII on, as an aid to the solution of problems of the kind mentioned.
6. Informal geometry[5] as a part of arithmetic from Grade VII on.
7. Mechanical computation if and when the school shall acquire simple types such as the future will certainly demand.

Besides these thing of an elementary nature there are the very important fields of accounting, technical training, national economy, and science. We have been faced by problems of tremendous importance to the country, of which one is that of isolation. How high can we raise the tariff walls, how completely can we live within our borders, importing little and exporting in the same proportion? There is also the problem of taxation—one that touches every home in America. These and others like them are essentially mathematical questions for our junior high schools, senior high schools, and junior colleges and they are well within the grasp of students in departments of education. What are we doing to answer them? Practically nothing for the average pupil. It is from such important storehouses that we can and should find material to replace what is now obsolete in arithmetic and algebra. But too many of our present teachers see these needs only in spots; they are blind to the problem as a whole. One teacher may do something with the economical question of buying on the installment plan, and another may venture upon the question of tariff, while a third may spend time on budgets or some useless labor on non-productive projects, but a new body of teachers must be trained to see the great importance of economics in all such fields.

All this is concerned with the blending of arithmetic and elementary algebra. The failure to realize that there is no definite boundary

[5] See page 79 of the Report of the Joint Commission (Fifteenth Yearbook of the National Council of Teachers of Mathematics) as to the nature of this work.

between the two is also a relic of two centuries ago.

The question of how the secondary school can adjust its curriculum to improve the abilities of its pupils and others in the community who may be needed in the armed services of this country is not as simple as the task facing the elementary school, but it is not impossible to make decided improvement. Brueckner recently said:

> The results of carefully constructed tests in mathematics administered to high school seniors and men in the Army throughout the country reveal an unsatisfactory condition. For example, on a 30-item test in the four fundamental arithmetic operations and percentage, all of the skills included being judged socially useful, the median score for over 90 high schools in all parts of the country was 17.3 items correct, or 58 per cent correct. Obviously, this is an unsatisfactory level of performance for those about to enter any branch of military life in which a fairly high degree of computational accuracy is desirable. The level of accuracy of a large group of Army Engineers was 85 per cent, which might be regarded as a minimum standard for our schools.[6]

Brueckner further showed by a series of experiments that by a short period of intensive, systematic practice with well prepared materials it is possible to produce a marked growth in arithmetic skill among high school seniors.

While such a plan may offer one solution to the problem stated above, in all of our high schools insofar as arithmetic is concerned, it is possible that an even better solution to the problem of establishing arithmetic ability may be found. I refer to the plan of at least a half year course in social-economic arithmetic in the senior year of the high school such as that suggested in the Fifteenth Yearbook of the National Council of Teachers of Mathemetics.[7]

Brueckner found that in the case of algebra there is a very large decrease in ability for pupils in the twelfth grade who have had only one or two courses in mathematics, usually algebra or geometry or both, taken in the ninth and tenth grades. He said:

> This fact has been established by the results of tests in algebra, given to students in typical high schools in the Midwest and would undoubtedly be true for all parts of the country. The test used was a carefully selected sampling of the items listed in the report of a committee appointed by the U. S. Office of Education to establish a valid basis for determining the content of preinduction courses in mathematics. This report appeared in *The Mathematics Teacher* for March 1943. It was based on a systematic study of the mathematics needed in the various armed forces, not including the highly technical branches in which a knowledge of the higher branches of mathematics is required. The analysis of essential skills for arithmetic, algebra, and geometry shows that they are quite simple and are much more limited in scope than the contents of most of our present day courses in these subjects. This information is of considerable value to committees engaged in planning preinduction and "refresher" courses in mathematics. It is quite clear that what is needed is not more courses in mathematics including a great deal of difficult material for all high school students, but rather the establishment of the simple basic mathematical skills indicated in the above report

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[6] Brueckner, Leo J., loc. cit. p. 203.

[7] See the report of the Joint Commission. Bureau of Publications, Teachers College, 525 West 120th Street, New York City.

that are needed by those who enter our armed forces. If these foundations are well established prior to induction, advanced training can be begun much sooner in those specialized areas for which the military authorities rather than the high schools should assume the responsibility.

It may be of general interest to learn that the ninth-grade algebra results showed that at this level the pupils had only slightly lower ability in the essential elements of algebra than is possessed by army engineers and preflight students enrolled in mathematics courses at the University of Minnesota. The very low scores by comparable groups of seniors who had had little training in mathematics beyond algebra and geometry shows that these skills deteriorate rapidly, in many cases practically disappear, due to disuse during the time interval between grades 9 and 12. Undoubtedly the reconstruction of basic algebra skills will prove to be a more difficult task than the review required for arithmetic. It is believed, however, that a short intensive review of basic essentials in algebra by means of well-constructed test and practice exercises will be adequate in most cases.

Various plans for "refresher" mathematics courses for those not now in the schools have been found to be very effective. In many localities classes have been established in evening schools in which large numbers of high school students and adults have enrolled with excellent results. Some mathematics workbooks contain diagnostic tests and self-helps which enable the individual to discover his weak spots and then to work out independently the explanations of procedures that are included and to carry out a program of selfdirected practice. In some places service centers have been established where assistance is given those who are attempting to do this review work unaided.

In addition to the above, other kinds of provisions can be made for students now attending high schools. Because of the wide range in the abilities of different individuals it is desirable that the needs of each student be established by systematic diagnostic tests. To reduce the teaching load these tests are often geared in workbooks to suitable study helps and practice exercises which are almost self-administering. In this way the work of the program can be individualized completely in terms of the needs of each individual. Refresher courses, or rather periods, are scheduled in the program so that they can be elected on a systematic basis by students wishing to undertake the work. It is not necessary to provide a regular teacher for this work, provided the types of materials described above are made available in some convenient spot. In some schools the review work has been incorporated in other courses, such as social studies, shop work, preinduction courses, and the like, organized practice being done once or twice during the week.[8]

As in arithmetic so in the other mathematical subjects in the secondary school certain changes would be helpful along with a renewed attempt to make mathematics not only more interesting but more useful by the introduction of more realistic applications all along the line. These applications of the essentials should be made to genuine problems in the fields of science, industry, air and marine navigation or other work of importance at the time.

In algebra we should omit the following:

1. Most of the present work in the operations with polynomials, such as have no application in social life, in ordinary business, and in science. These are relics of two or three centuries of wasted energy.
2. Most of the mere puzzle and uninteresting "applied" equations, the time being given to work mentioned below.

[8] Ibid. p. 203.

3. Elaborate cases of simultaneous equations, especially such trick solutions as have no applications in science or industry.

In algebra we should add the following:

1. A much greater use of the equation in the manipulating of formulas actually needed in connection with
   a. Physical problems, the meaning and significance of which are within the grasp of the pupils.
   b. Commercial problems.
   c. Problems relating to social activities—graphs, investment, support of government, budgets, household interests.
2. Series as related to pupils' interests—population, compound interest, physical problems, simple computations by logarithms (leading to the explanation of the slide rule), and other social needs.
3. A more purposeful use of the idea of function, of dependence of one variable upon another. In particular such dependence as relates to business, to science, and to the problems of daily life.
4. A more intimate relation of physical problems to algebra as has long been cultivated in European schools and as is suggested in No. 1 above. The lack of this recognition is one of the greatest weaknesses in the teaching of algebra in America. To overcome it requires a radical departure from the present training of teachers of mathematics. Our teachers of the entire subject must know more of the science and of the applications of mathematics to the life of the twentieth century. Opposed to this will be many general educators who look upon the matter solely from the standpoint of the theory of teaching. We must start *de novo* in the training of teachers of mathematics if we wish to succeed.

In geometry it will be necessary to omit:

1. About two-thirds of the traditional propositions to be proved fully. The real purpose of logical geometry can better be secured by retaining only the necessary basal propositions, introducing more original matter, and reducing the deductive aspects of the course for many pupils.
2. All attempt at remembering definitions and statements of propositions, thus replacing mechanical methods by real thinking. In particular, abandon all attempts to define the indefinable and minimize the ultra-logical beginning of geometry.

In geometry we should add:

1. A modern beginning, establishing the truth of the propositions informally. This movement is already under way.
2. A more carefully planned use of models including some for solid geometry made by the pupils so as to have geometry seem more real.

3. A large number of applications to science. Here we have hardly made a beginning.
4. A number of abstract exercises, applying logic to new situations, particularly to thinking about life's problems. Here we have made a fair beginning.
5. The idea of generalizing propositions, especially in the study of varied shapes of the standard figures. This will introduce the negative line, angle, and area, opening up a field of interest new to the pupils. For this we need much better-trained teachers, not only in the theory of education but also in the modern field of geometry.
6. A large number of applications to the science of Air and Marine Navigation.[9]
7. A simple introduction to analytic geometry especially for the gifted pupils.

In trigonometry we should, except for pupils who show unusual ability, omit:

1. Those parts of the subject rarely used except in the highest computations of astronomy. I refer to a considerable part of the work in trigonometric equations and to the formulas for half-angles except where real applications are available.
2. Trigonometric formulas in general except as needed in ordinary work in physics and elementary astronomy.

In trigonometry we should also recall the fact that the subject is essentially a part of algebra and has relatively little relation to theoretical geometry. Here, again, we must begin *de novo* the training of teachers. In particular:

1. The whole subject of the imaginary number rests chiefly on trigonometry. This can be easily introduced in the high school, but we need a new generation of teachers to realize its importance. The whole theory of vector analysis starts here, and although not suitable for the high school (except for the parallelogram of forces) it is easily taught to college freshmen.
2. The elements of trigonometry are much easier than the relatively useless material which should be dropped from high school algebra.

In college algebra there should be dropped (always excepting the highly-gifted mathematician) all that cannot be used later in mathematics or in elementary science. This should be replaced by work in analytic geometry or the calculus.

Analytic geometry is today taught about as it was in the eighteenth

[9] See Bradley, A. D., *Mathematics of Air and Marine Navigation*, American Book Co., New York, 1942. See also Osteyee, George, *Mathematics in Aviation*, Air-Age Education Series. Macmillan, New York, 1942, and the 17th Yearbook of the National Council of Teachers of Mathematics, *A Sourcebook of Mathematical Applications*. The Bureau of Publications, Teachers College, 525 West 120th Street, New York City. Now out of print.

century—with no apparent purpose to arouse and maintain interest. Its application to algebra, elementary geometry, physics, and astronomy is generally neglected.

There is here a rich field for the training of an entirely new brand of teachers, with new interests and with new vision of the beauties and the utilities of the subject.

The calculus should abandon its present introduction as written by mathematicians for mathematicians. As it stands at present, it is too often taught as it was a century ago.

To begin with a rigid, ultra-logical presentation of the subject is to discourage almost all students. It is like the old way of teaching a foreign language by devoting the first few months to ultra-technical grammar.

We should begin with simple applications, apply intuition and solve many problems. After all this, we should give the rigid theory to such as can absorb it.

Finally then, there seem to be two types of changes for the coming curriculum in mathematics:

1. Revisions of mathematics and science content to provide illustrations and applications.
2. A new drive toward a more complete mastery and sane ability to transfer mathematical and scientific learnings to practical situations.

Many years ago in a previous article I tried to make these same points by quoting Sir Percy Nunn. He said:

> Mathematical truths always have two sides or aspects. With the one they face and have contact with the world of outer realities lying in time and space. With the other they face and have relations with one another. Thus the fact that equiangular triangles have proportional sides enables me to determine by drawing or by calculation the height of an unscaleable mountain peak twenty miles away. This is the first or outer aspect of that particular mathematical truth. On the other hand I can deduce the truth itself with complete certainty from the assumed properties of congruent triangles. This is its second or inner aspect. The history of mathematics is a table of ever-widening development on both these sides. From its dim beginnings by the Euphrates and the Nile mathematics has been on the one hand a means by which man has constantly increased his understanding of his environment and his power of manipulating it, and on the other hand a body of pure ideas, slowly growing and consolidating into a noble rational structure. Progress has brought about, and, indeed, has required, division of labor. A Lagrange, or a Clerk Maxwell is chiefly concerned to enlarge the outer dominion of mathematics over matter; a Glauss or a Cantor seeks rather to perfect and extend the inner realm of order among mathematical ideas themselves. But these different currents of progress must not be thought of as independent streams. One never has existed and probably never will exist apart from the other. The view that they represent wholly distinct forms of intellectual activity is partial, unhistorical, and unphilosophical. A more serious charge against it is that it has produced an infinite amount of harm in the teaching of mathematics.
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> Our purpose in teaching mathematics in school should be to enable the pupil to realize, at least in an elementary way, this two-fold significance of mathematical progress. A person, to be really 'educated' should have been taught the im-

portance of mathematics as an instrument of material conquest and of social organization, and should be able to appreciate the value and significance of an ordered system of mathematical ideas. There is no need to add that mathematical instruction should also aim at 'disciplining his mind' or giving him 'mental training.' So far as the ideals intended by these phrases are sound they are comprehended in the wider purpose already stated. Nor should we add a clause to safeguard the interests of those who are to enter the mathematical professions. The treatment of the subject prescribed by our principle is precisely the one which best supplies their special needs.[10]

No curriculum that we might formulate can be successful unless we have strong teachers to administer it.

Too much time has been spent on computational arithmetic, and often of a very low order at that, insofar as the real needs of society are concerned. This situation should be remedied immediately.

To make mathematics education function at its highest in this country we need to evaluate anew not only the materials of instruction, but also to improve our methods of teaching and learning mathematics. The improvement of content makes necessary a reshaping of aims and the development of a new nation-wide cooperative program. The improvement of teaching and learning will involve the raising of standards for teachers entering the profession and improved opportunities for the further education of teachers in service.

Mathematics has been adapted to mass education. The natural result is a lowering of scholarship, a leveling down instead of a leveling up, but an increase in influence which on the whole will result in good because more people will have a chance without necessarily jeopardizing our opportunity to discover the pupils of genius.

The fact that our country is new and that the high school population has increased so fast in the last thirty years (it is now close to 7,000,000) has made it impossible for us to demand as high qualification for teachers as we should like to have had.

Another significant factor is the fact that our unprecedented industrial and economic growth has resulted in men leaving the teaching procession to go into other lines of work. Due to the war, the exodus of male teachers was not only large, but alarming. Even women left the teaching profession to take up some sort of war work. While we may admit the natural superiority of women with children, we must not fail to realize that for many of our women teaching is not a permanent profession. What is the mental effect? I think it has led to a lack of interest in the proper preparation and background for teaching mathematics in the schools. As a result we do not have among either men or women teachers enough people of scholarly minds. The mathematical background of many of our teachers is decidedly limited to say nothing of their deficiencies along other lines.

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[10] Nunn, T. P., *The Teaching of Algebra*, Longmans, Green, London, 1927, pp. 16–17.

Many people are teaching mathematics in the secondary schools today who have not had any mathematics courses of collegiate grade. The situation is even worse than that in some places. When a superintendent of schools insists on putting a teacher, who has had no mathematical training, in charge of high-school classes in mathematics because he has no other use for him, the situation is unsatisfactory. Even now when the shortage of teachers is so acute, the policy of delegating people, who are not prepared to teach mathematics may be worse than no teacher at all, unless of course they seek immediate preparation. The National Council of Teachers of Mathematics, the Central Association of Science and Mathematics Teachers and other groups of leaders in mathematics education should begin to study such practices and make plans to improve them. We could do this if we had sufficient group consciousness, group loyalty, the courage of our convictions and some financial help.

If we are to make an attempt to improve the mathematical situation in this country, the following suggestions should be helpful:

1. Two types of scholarly men and women should be developed: First, research scholars whose major interest is to expand mathematics vertically; secondly, teacher scholars who are primarily interested in the horizontal expansion of the subject.

2. We need courses in methods and in professionalized subject matter for students who intend to be college teachers of mathematics. The teaching of college mathematics in many places is far below the standard.[11]

3. There is no question that salaries of teachers in this country should be raised so as to attract capable men and women who will remain in the teaching profession. When that is done, we shall have to raise our academic requirements as well if we are to bring about genuine reform. I recently read about a teacher who resigned a position paying $70 per month to take a position in government service at $70 per week.

Already the increasing number of college graduates with good academic background in mathematics who are enrolling in our teacher training institutions in America augurs well for the future. Now that the war is over we shall have an oversupply of candidates for teaching positions. We should now be able to raise our standards and employ only the best of all those who are available.

4. It seems to me that we might require some training in science, at least in physics, of all prospective teachers of mathematics. In some schools in America the work in mathematics is already being correlated in this way.

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[11] Seidlin, Joseph, *A Critical Study of the Teaching of Elementary Mathematics*. Bureau of Publications, Teachers College, 525 West 120th Street, New York City, Contributions to Education, No. 482.

5. We must cooperate with subject matter specialists in other fields in demanding more recognition on the programs at such general educational meetings as state associations, sectional meetings, and teacher institutes. Some state associations are so completely under the control of secretaries (often men of meager academic training), that it is almost impossible for a subject matter group to secure any outside talent without themselves providing the necessary funds. As Pierce[12] put it "Convention speakers rarely present a topic which has even remote value to the teacher's problems in the classroom. Most of them advance their pet theories, discuss their research work, or talk about economic or political problems with which they are none too familiar. Most teachers go to Conventions to receive instruction on the nature of the child and his proper nurture. High sounding phrases, patriotic oratory, or research dissertations hold little of interest and less of value to the average teacher."

6. As fast as we improve the teachers of mathematics we can lift the level of the articles in all the journals for mathematics teachers. However, we shall still face the problem of getting these publications in the hands of teachers where they will be more widely read. While it may be a surprise to some, there are plenty of mathematics teachers who do not even know that there is such an organization as the National Council of Teachers of Mathematics or the Central Association of Science and Mathematics Teachers.

It is no exaggeration to say that we should have a membership of at least 10,000 in the National Council of Teachers of Mathematics. If we can publish and distribute free monographs to our present members, this will do a great deal to augment our national growth. Financial difficulties due to lack of general support among mathematics teachers makes this hard to accomplish.

Since the epoch-making report of the National Committee on Mathematical Requirements[13] on "The Reorganization of Mathematics in Secondary Education," in 1923, we have been able to carry on the work started by this committee and to approach the problem of mathematical education from a national point of view through the work done by the recent Joint Commission of The Mathematical Association of America and the National Council of Teachers of Mathematics[14] on "The Place of Mathematics in Secondary Education" and, more recently by the Commission on Post-War Plans of The National Council of Teachers of Mathematics.[15]

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[12] Pierce, A. Lester, "Why Teachers Duck Conventions." *The Clearing House*. November, 1942, p. 174.

[13] A report prepared under the auspices of the Mathematical Association of America.

[14] Ibid.

[15] See *The Mathematics Teacher*. May 1945 and November, 1947.

Immediate Needs and Plans

Now, if ever, is the time to develop nation-wide cooperation in mathematics covering the schools previously mentioned. It should not be controlled by any extra mural examination boards and should contain what the leaders who cooperate think should be the mathematics of the future. It seems absurd that we should spend the energy and money, as at present in this country, in order to produce all of the various state and city syllabi with the result that they fail utterly to meet the needs of the hour. The results of such a cooperative effort should be accompanied by a teachers manual, the purpose of which would be to give helpful suggestions to the teacher as to what should be done in the classroom.

FIVE MILLION PICTURES A SECOND

A new motion picture camera which will take more than 5 million pictures a second was described at the Thirty-Second Annual Meeting of the Optical Society of America, by Dr. Brian O'Brien, Director of the Rochester Institute of Optics at the University of Rochester.

When a motion picture of a rifle bullet, taken by the new technique, is projected on a screen at the usual speed, it requires a minute to show one inch of the bullet's movement.

The camera is ten times as fast as any previously made and is expected to reveal new scientific information about electrical charges, high explosives, and shock fronts important in the study of supersonic flight, according to Dr. O'Brien.

The camera is shutterless and uses a flash lamp with a flash duration of 1/5000th of a second, about 100 times as fast as a news photographer's flash bulb. The principal feature of the new camera is a device which dissects the image on the original film so that segments of a few hundredths of a millimeter each become frames for exposure in an ordinary 16 millimeter projecture.

Gordon G. Milne, research associate in optics at the Institute, worked with Dr. O'Brien in development of the new camera.

INGRAM RECEIVES RESEARCH GRANT

William Marcus Ingram, professor of zoology at Mills College, has been honored by a research grant from the American Philosophical Society, one of the most learned societies in the United States. This grant will aid Dr. Ingram in his studies of land and fresh water mollusks of the Oakland-San Francisco bay area.

This is the second research award that Dr. Ingram has received in the past two years. A year ago, the National Scientific Research Society of Sigma XI paid tribute to Dr. Ingram's research ability and named him as recipient of their 1946 grant. As a result, Dr. Ingram how has published a scientific monograph book on certain fossil shells found along the coasts of North, Central and South America.

During the summer of 1943, Dr. Ingram was a research member of the Woods Hole Oceanographic Institution for the United States Navy. He has contributed to nearly a score of journals of biological and scientific nature.

At Mills since 1941, Mr. and Mrs. Ingram and their three children, Leslie Ann 6, William Nicholas 3 and Carolyn Ruth, age 1, live in Faculty Village on campus.

COVERING OLD AND NEW GROUND*

M. M. Leighton
Chief Illinois State Geological Survey, Urbana, Illinois

Ladies and Gentlemen of my radio audience: Geology is one of the great sciences devoted to the study of the nature of the world and of man. It concerns itself with the origin of the earth, the changes through which it has gone, the constitution and structure of the earth, its surface features, the history of life, and the geological resources that are useful to man.

All science is rooted in the dim and distant past. Man has always been interested in nature and has given thought to it since the day he became a reasoning creature. In the beginning the world was a mystery to him, and his gifts of perception and his fund of knowledge grew very slowly through thousands of years. Science as we know it today is of recent origin. Just as we speak of the new physics and the new chemistry, so we can speak of the new geology, the new botany, the new zoology, and the new other sciences. Every new discovery in one science has its effect upon the development of the related sciences. Thus science is dynamic and ever-changing.

Geology began to emerge and take form as a science in its own right less than two hundred years ago. It is primarily a nature science. Its body of information must come from studies intelligently made in the field, supplemented by more detailed physical and chemical studies in the laboratory. For fifty years after the Revolutionary War, false concepts progressively gave way to sound concepts, and information on the geology of the eastern half of the continent increased rapidly. Immediately following the Civil War geological explorations were extended into the western part of the continent. Universities and colleges began to establish departments of geology early in the nineteenth century, state geological surveys began to be organized about 1830, and the United States Geological Survey was founded in 1879. During the past thirty years the number of geologists has increased enormously due to the need for them by the petroleum industry, mining, engineering, and other fields. At present there are something like ten thousand geologists engaged in the science, indicating its importance today.

Geology has become a great science in even more important respects than the size of the profession. It now comprises many subdivisions, in each of which there is high specialization. There is, for example,

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* Radio address presented over KODI, Cody, Wyoming, Thursday, August 7, 1947, on the occasion of the Geological Field Conference in the Big Horn Basin, under the sponsorship of the University of Wyoming, Wyoming Geological Association, and the Yellowstone-Big Horn Research Association, and with the Fellows of the Geological Society of America as special guests.

the special field of physiography which is a study of the surface features of the earth. Recently, Dr. Eliot Blackwelder, a distinguished American geologist, spoke to us over the radio about the face of our continent as you and I would survey it from an airplane enroute from Washington to San Francisco. On this imaginary airplane trip he took us across the Appalachian ranges and pointed out their parallel ridges alternating with valleys, with large rivers winding through many of the valleys. He pointed out that the rivers were the agencies which carved out these valleys and that the valleys came to be where they are because the rocks there are soft whereas the rocks in the ridges are hard, and that they occur in belts because the layers of rock had been uplifted from the sea and corrugated into parallel folds.

Flying on westward, he pointed out the great Central Plains extending from Ohio to Colorado, a country not characterized by long belts of ridges and valleys but by dendritic drainage systems corresponding in form to the veins of a leaf. Below the soil of this rich farming country, he informed us, the rocks lie nearly flat as they were originally laid down in the ancient seas. Thus, when they were uplifted above sea-level, the drainage that developed on the rocks of approximately equal hardness took on a branching pattern. This drainage of the interior plains is in striking contrast to the trellised drainage of the parallel valleys and ridges of the folded Appalachians.

Approaching Denver, Dr. Blackwelder pointed out the Front Range of the Rocky Mountains, rising like a wall. This mountain block—once a part of the plain—was bent up sharply so that the erosion and stripping off of the overlying soft strata were accelerated and the underlying granite and other hard rocks have been gradually uncovered. They have been cut by streams into a most interesting and scenic complex of canyons and ridges to form the rugged Rockies.

Winging farther westward, Dr. Blackwelder carried us over the sage-brush steppes and the mountains of Utah and Nevada to California. And, to quote him, "There the Sierra Nevada rises above timberline with the sharp rocky peaks that indicate the former presence of glaciers upon their sides." Beyond them lies the great California Valley, formerly a bay of the Pacific Ocean, now a plain built up by the streams which descend and carry debris from the bordering mountains. The Coast Ranges bordering the Pacific are low mountains now being slowly folded and uplifted at the rate of inches per century but more rapidly than erosion can destroy them. Therefore we have a measure of how slowly and unobtrusively, yet invincibly, Nature works. Already the Coast Ranges are high enough to affect the rainfall to the east and the plant and animal kingdoms of the California Valley.

Anyone can take up the study of the physiography of the earth or

of his continent and gain an acquaintance with the ways of Nature that will revolutionize his intellectual state, give him poise in his philosophy of the world, and make him a better parent and companion.

Historical geology is another division of geology that would help to satisfy one's curiosity and desire to become more fully acquainted with Nature. By historical geology, I mean the history of the earth and its inhabitants—the animals and plants. Let me suggest that you start with the origin of the earth and learn how it is harmoniously related to the other planets of our solar family, why it appears that the earth was once a growing body but is now contracting, and how it is learned that the oldest known rocks are nearly two billion years old. Then follow the successive eras and learn why we believe that the great segments of the earth—the continental masses and the oceanic basins—have been permanent but that various parts of the continents have been repeatedly submerged by broad shallow arms of the oceans; how the history of these great earth events is determined, and how the relative ages of the various mountain ranges can be told; how we can interpret the past climates of the earth and why there is reason to believe that there have been some changes in the composition of the atmosphere; how the record of life from the earliest ages is read and what a marvelous record it has been. These facts give stability to one's thinking and become guideposts by which one can judge all sorts of philosophic speculations, ideas, and religious creeds. Above all, they teach humility, love of truth, and respect for the forces of Nature and behind Nature. You may recall the expression of Edwin M. Stanton, Secretary of War, at the death-bed of Lincoln: "Now he belongs to the Ages." One who is conscious of what geologic time means and of the infinite economy of Nature in both the spiritual and material sense knows the great significance of that statement.

A third subdivision of geology which might well fascinate you is structural geology. If you were to follow this subject there would be two possible diversions of interest: one, the structure of the earth's interior which would be especially attractive to those of you who have a bent for physics and chemistry, and the other, the structure of the earth's crust including the lofty monntain ranges, the great basins, the high plateaus, the low subdued plains, and the ocean basins. I should perhaps extend the note of warning that whichever you were to choose—the earth's interior or the earth's crust—you would soon find that the division is wholly arbitrary and unnatural and that the two have genetic relationships that you would want to follow through. If you were to start with mountains and basins there is no better point to launch your inquiry than right here in the Big Horn Basin, where the features that hold such scenic interest for you and your

guests from far away places possess a source of knowledge and inspiration for you that we from the plains look upon with genuine envy. Before you have gone far in your avocation you will have found such a feast for the mind, such a new outlook upon the world, such a thankfulness that you are able to view Nature in its true light, that you will declare with the psalmist, "I will lift up mine eyes unto the hills, from whence cometh my help."

Some people love to collect and identify, and they become surprised with the educational values of such an adventure. To those of you who lean that way in the realm of nature, mineralogy holds a volume of interest and a multitude of ties with the world about us. One can run the whole gamut of minerals from graphite and talc to the metallic minerals and the gems and precious stones, their crystal forms and the laws that govern them. In the beginning, specimens of single minerals will be of chief interest but eventually and logically composite specimens of ore minerals in their natural relationships will come to your attention and also the rock-forming minerals and the great families of rocks. By this time you will be coupling mineralogy and petrology, the science of rocks. The Big Horn Basin and the adjacent areas of Yellowstone National Park and the Tetons are places where I suspect the Boy Scouts excel in their knowledge of minerals and rocks. Perhaps some of them have become amateur mineral economists or youthful statesmen on the national importance of mineral resources.

What has been said about mineralogy applies equally well to paleontology, the science of fossils, or better still, the science of past life. The region about Cody illustrates the well-known biblical quotation: "The low places shall be made high," for there are hosts of outcrops, in the basin and on many mountain slopes, of sedimentary layers originally laid down on ancient sea-bottoms, which contain many shells of marine forms that lived during those ages when Cody was not the Cody of today but a spot in the Jurassic sea or the Cretaceous sea. What fun it is to compare these fossils with forms that you will collect the next time you visit the seashore or exchange with a friend who lives there. Another fine interest in this connection is to trace some of the ancient life forms down to the present and get that breadth of view and understanding that comes from knowing how long it has taken Nature to produce the life of the present. In the case of the larger forms like the birds, the dinosaurs, and the mammals, a person can resort to collecting photographs from museum and other scientific publications. By all means, if your interest runs to life, do not pass up paleontology.

Now I have, up to this point, called the roll of most of the subdivisions of the modern science of geology—physiography, historical

geology, structural geology, mineralogy, petrology, and paleontology. There is one more division which if omitted would be to ignore the modern industrial life of America and our high standards of living—namely, economic geology. The veracity of this statement may be confirmed by a listing of its branches.

First, petroleum geology. The petroleum industry employs more than half of all the geologists in America, which reflects how important the scientific finding of oil has become. Moreover, America moves on wheels powered by oil and its products.

Second, mining geology. Nearly 20 percent of all of the geologists of this country are employed by mining companies and other industries. Our type of national economy has flowered because of the products of mines and quarries.

Third, engineering geology. Engineering geologists perform vital functions in seeing that dangerous features of foundations for dams for large reservoirs are eliminated to make them safe for life and property, that the problems of the occurrence of groundwater are understood, that the geological pitfalls of highway construction and maintenance are recognized and solved, and that other aspects of earth materials and conditions are understood before the engineer of design or construction completes his work.

The importance of economic geology is thus seen to have become highly essential to modern life.

The next few minutes we shall devote to the educational relationships of geology. The universities and colleges of this state and of this country are the torch-bearers of human knowledge from the generation that is passing to the generation that is coming. They also carry in large degree the responsibility, first, to conserve the sum of knowledge, and, second, to improve and extend it. The training of competent and inspiring teachers and of creative research men and writers is of the utmost importance to all branches of knowledge. As one of the great sciences, geology looks to a great future through the work of these institutions in training men.

Educators throughout the world consider this to be a time for introspection. They look upon that period between 1919 and 1939 as a period when a great victory was thrown away with a rapidity and a completeness unexampled in history. They are asking, is this an age without standards, an age without knowledge of the science of good and evil, an age without a goal towards which to set our course? Sir Richard Livingstone, the great English educator, reminds us that "human beings have bodies, mind and character," each of which is capable of "virtue" or "excellence"; that "education is a handmaid of the art of living"; and that "the true teacher develops the mind without weakening the character."

"University teachers," he continues, "are familiar with a type of boy who is well-educated in the conventional sense, but who has no clear philosophy of life, nothing to fall back on in the hours of stress, discouragement or indolence that all men experience: who is easily swept off his feet by current sophistries or the fashion of the hour, and the voyage of whose life, even if he escapes these, tends to be 'bound in shallows'."

Is it not possible that the omission in our secondary schools of fundamental subject matter dealing with the nature of the world and the history of life upon it and our relations to the great economy of things—material and spiritual— is an important factor in this lack of a clear philosophy of life and in man being "bound in shallows"?

I am reminded of Shakespeare's statement in "Measure for Measure": "The law hath not been dead, though it hath slept."

GRAVITATIONAL FORCES AND THE PENDULUM

Martin H. Patrick
903 Chestnut Street, Kulpmont, Pa.

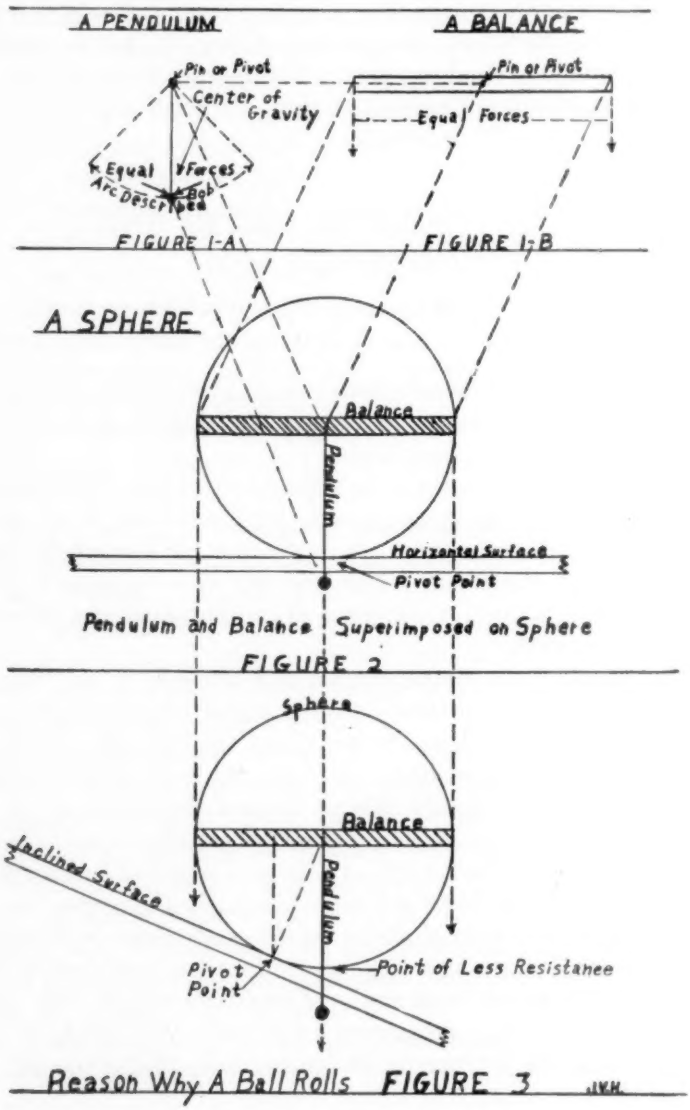
Strange as it may seem, the same natural law governs the action of a pendulum, balance, and a sphere. An understanding of this can be gained by a few home experiments.

First it must be recognized that the earth exerts a downward pull or force commonly known as gravity. This force acts on all materials alike. Not only does the force act on the matter as a whole, but also on each minute particle of which the matter is composed. The net result of all these forces is a single pull concentrated at a point called the center of gravity.

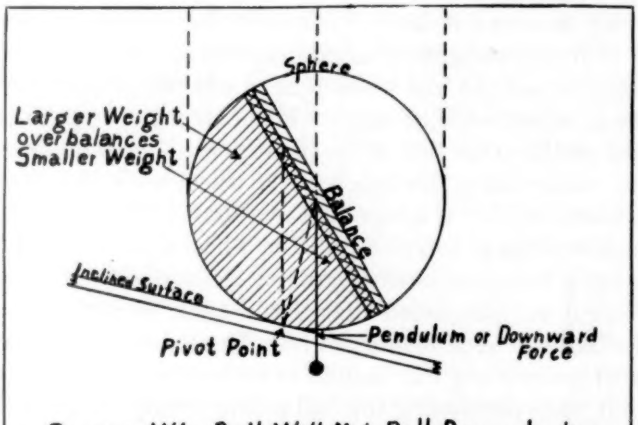
Let us consider the simplest form and progress to the more complex. Suspend a piece of thread from a pin or tack and attach a bob so as to make a pendulum. The weight of the bob will exert a downward force against the point to which the thread is attached, forming a straight line which points directly toward the center of the earth. This line represents the center of gravity and theoretically is said to be exceedingly thin. Now support a strip of wood or similar material by a pin or needle so that the hole is in exactly the center. See figure 1-B. Now move the pendulum to one side and release it; it will move back and forth describing a large arc at first, and continue in shorter arcs until it has spent its energy, and has come to rest. The reason is that gravity, exerting a downward force, ultimately brings it to rest. Likewise cause the balance to cradle, and note that it too will finally

come to rest. The reason is the same. The forces of gravity act on all parts of the balance equally, and finally bring it to rest in a horizontal position. Place a small weight on one side of the balance and note that it overcomes the force of gravity by causing the balance to tilt.

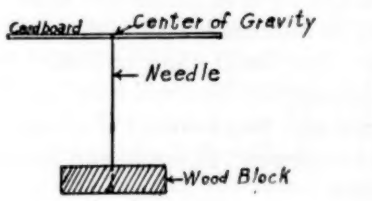
Let a ball rest on a flat surface. Why does it not roll? To answer this question, superimpose the two previous drawings one upon the other, and using the pivot point as center, describe a circle around them. See figure 2. Note that the point of balance is common to all three; namely, the pendulum, the balance, and the sphere (ball).



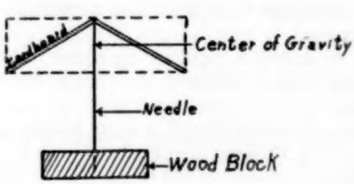
Since the pendulum and balance at rest are caused by gravitational forces equally distributed, it follows that the ball or sphere at rest is caused by the same forces. One needs to consider only the fact that the lower portion of the ball (as well as the upper portion) is divided into two equal parts, and since gravity exerts an equal pressure on each part, the result is a perfect balance. At this time it must be recognized that the ball touches the surface at only one point which serves as a pivot, and that the pendulum touches at exactly this point.



Reason Why Ball Will Not Roll Down Incline
FIGURE 4



Difficult to Balance
FIGURE 5



Easy to Balance
FIGURE 6

Now tilt the surface and the ball will roll. Why? Considering figure 3 note that the pivot point has been moved to the right, away from the line of center of gravity as represented by the pendulum, and since the force at this point represents a point of less resistance as compared to the pivot point, the ball must roll in this direction. Look at it this way: If a rope tied to the shaft of a wheel be pulled directly down, the wheel will not move; but, if the rope be pulled a little to the left or right—away from the center of gravity—the wheel will move in that direction.

To prove this, cut a ping-pong ball in half. Into one half insert just enough clay to make it level. Pack well. Now glue the two halves together with airplane glue. Place the ball on an incline plane of about thirty degrees, and the ball will refuse to roll. Why? Because the pull of gravity as represented by figure 4 is not strong enough to overcome the weight on the other side of the pivot point. The same idea may be gained by recognizing the sphere as a wheel with the shaded area filled with lead or iron. If a rope tied to a shaft in the center be pulled, it will require a great force to pull the wheel around. In the case of the ping-pong ball, the force of gravity is insufficient to accomplish this. It might be mentioned that if the angle of inclination be too great, the ball will slide instead of roll. The reason, of course, is that the force of gravity is great enough to overcome the resistance at the pivot point, thus permitting the ball to slide freely. It might be noted at the same time that the energy required to start the ball sliding is greater than that required to keep it sliding.

Take a straight piece of cardboard about two inches long and one-half wide. Try to balance it on the blunt end of a needle. This is next to impossible. Now bend the cardboard into an inverted "V" and again try to balance it. You will have no difficulty. Why? When you bent the cardboard, you lowered the center of gravity considerably, as shown in the drawing, figure 6, and brought about what is called a stable condition.

THIN TUNGSTEN WIRE IS INVISIBLE TO EYE

Tungsten, the metal that is used for light bulb filaments, has been made into a wire here that is so thin that a pound of it would stretch in a single strand 950 miles.

The wire is 0.00018 inch in diameter, and was produced here by the Westinghouse Lamp Division for use in an amplifying tube for the Bell Laboratories.

One thousand feet of the thin wire, reeled on a bobbin, is invisible to the naked eye, and a 20-layer stack of the wire is about the thickness of a sheet of newspaper.

HELPING STUDENTS VISUALIZE RELATIONSHIPS BETWEEN GAS VOLUMES AND CHEMICAL REACTIONS

ROBERT H. LONG
Green Mountain Junior College, Poultney, Vermont

The problem of teaching clear understandings of the relationships between gas volumes and chemical reactions can be to some extent solved by the use of 22.4 liter cubes, weighed amounts of solid substances and knock-down block models of molecules. The cubes can be made easily form cardboard box stock. Seven or eight will be sufficient for most demonstrations. The weighed moles of solids should be placed in bottles with large labels bearing the number of moles and the total gram-molecular weights. The models of molecules can be made from wooden blocks and put together with hard wood pegs, which represent valence bonds. Care should be taken in spacing the holes for the pegs so that atoms can easily be interchanged in building the product molecules from those representing the reactants.

With the increasing numbers of students who enroll in science courses, in order to gain an understanding of the subject areas for background and general educational purposes, there comes special demands upon the instructor to devise teaching methods that lead to clear concepts in the minds of students who are not naturally inclined toward the sciences. The problem in many cases has been evaded by dividing the students into two groups. The one group consisting of those who seem to have natural ability for the sciences—especially the physical sciences. Thus, we have college preparatory courses in high school and pre-professional courses during the first two years of college. These in themselves are without doubt sound. The other group, composed of students, who we say lack the ability to study science quantitatively are often rounded up into consumer courses or survey courses that are stripped of quantitative concepts to a point that they can hardly pass as science courses. And to further remove the element of science from them they are conducted without affording the students the first-hand experiences of laboratory work. The excuse is, of course, that persons who do not show a natural tendency to follow the sciences cannot think quantitatively. The truth is that in many cases all that is needed is some real help in forming clear pictures or relationships. Aids that a teacher may develop to help this group will be well repaid for in opening up new areas of understanding to the boys and girls who can profit greatly from good science education. And the responsibility becomes increasingly important as physical science principles enter more and more into our daily lives.

To return to the problem of gases as an example. In the study of chemistry as soon as students are acquainted with molecular weights and gram-molecular the idea of gram-molecular volume can be introduced along with a cube of 22.4 liters in capacity (Avogradro's Law can be gradually arrived at). With the knowledge of the composition of air and that density of a gas can be approximated by dividing the molecular weight (to be more exact the gram molecular weight) by 22.4 the relative weight of a gas as compared with air can be estimated at any time a comparison need be made. For example, the student knowing that the density of air would be somewhere between 28/22.4 and 32/22.4, and because of the greater percentage of nitrogen in air the volume would be slightly greater than twenty eight, he could reason very quickly that 2/22.4 or 17/22.4 would be

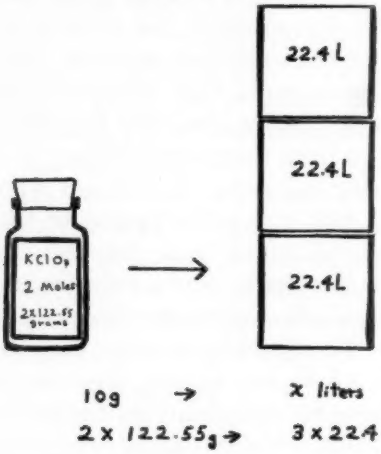


FIG. 1

less than air in density. Thus, as each gas is introduced for study its relative weight can quickly be reasoned out. It seems unnecessary to defend the use of a reasoning process in place of memorizing a fact.

Before weight-volume problems are assigned, as for example, in preparing oxygen from potassium chlorate, the equations can be balanced and then the students can be shown a bottle containing two gram-molecular weights of the chlorate. From the equation let the students figure the moles of oxygen formed. When this has been done they can suggest how many units of 22.4 liters will be occupied by the gas. Then three cubes can be placed beside the bottle containing the moles of the potassium chlorate (Figure 1). Once the students see that two gram-molecular weights of the solid will yield to three gram-molecular volumes they will follow in the next step that, for instance, ten grams of the chlorate will yield a proportional volume of

gas. The formula for weight-volume problems can be worked out at this point. Those trick steps of 3×22.4 or 2×22.4 become meaningful to more students and more subject to reasoning. For further practice

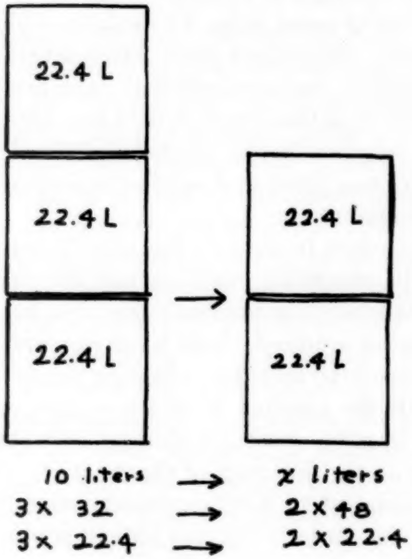


FIG. 2

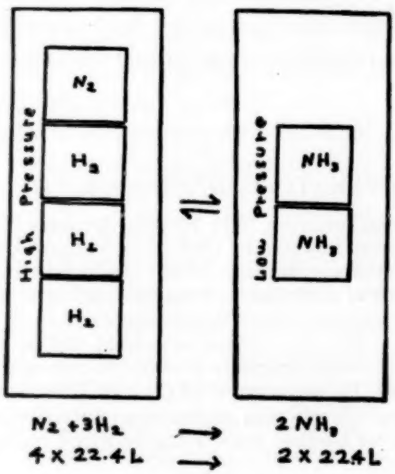


FIG. 3

the same procedure can be applied in determining the volume of sulfur dioxide formed when a given weight of sulfur is burned.

When the preparation of ozone is discussed the equation for its

formation can be balanced. Then three cubes representing the gram-molecular volumes can be exhibited. The students can suggest the volumes of ozone formed and the corresponding number of cubes stacked up to represent the product (Figure 2). Here again models of molecules will be of great help. The volume-volume problem solution will be almost self-evident here. After several similar examples have been worked out the students will have made a generalization that is the substance of the Gay Lussac Law, before the law is formally met in the text. Leading students to generalizations that clarify the basic laws to be studied and applied makes science all the more interesting in the classroom.

The effects of certain factors on the rate of chemical reaction in a given direction in reversible reaction can be clearly demonstrated by using the gram-molecular volume cubes. For example, in the study of the preparation of ammonia from hydrogen and nitrogen the reactants can be represented by three cubes for the hydrogen and one for the nitrogen while the product is shown as two volumes (Figure 3). With some well directed questions students can easily reason out the effect of pressure on the direction of the reaction. Thus, they can gain a simple visual concept of how increased pressure would favor the reaction toward ammonia formation and so a principle of chemistry becomes clearer to students other than those who expect to be chemists or engineers.

A phase of good science teaching should be a clear understanding of the basic principles that can be applied generally to the environment and ability to recognize these principles in a simple quantitative way.

"BROADCAST OPERATOR'S HANDBOOK," OUT IN JANUARY

John F. Rider Publisher, Inc., 404 Fourth Avenue, New York 16, N. Y., announces for publication in January 1948 of "Broadcast Operator's Handbook" by Harold E. Ennes, engineer, Station WIRE, Indianapolis, Ind.

While a vast amount of material on the technical aspects of putting programs on the air has been published, up to the present time there has been a dearth of written information on the part that a broadcast station personnel play in the scheme of things—and this is especially true in the case of the operators.

To fill this lack, Mr. Ennes, with WIRE since 1936, has written "Broadcast Operator's Handbook." Herein will be found a comprehensive treatment of the control room, the master control, remote controls and transmitter operation and maintenance.

In other words, here are co-ordinated facts that result in a general set of rules that can serve as standards of good operating practice—a new approach to modern operating technique and a discussion and clarification of existing facts that should lead to a better understanding between studio and transmitter personnel, thereby raising the level of operating practice.

TEACHING THE CARROT ROOT CORRECTLY

JOSEPH P. MCMENAMIN
Oak Park Township High School, Oak Park, Illinois

Probably there is no root more widely used for the demonstration of root structure than that fleshy storage organ of the carrot. Nevertheless there still prevails a general misunderstanding as to the internal anatomy of the carrot. This is not surprising since there are textbooks published as recently as 1947 in which the sectional drawings of the mature carrot are inaccurately labeled.

The chief error lies in indicating the tissue outside the cambium as "cortex." This was pointed out by Esau (1940) who showed that the so-called cortex is composed chiefly of secondary phloem, the actual cortex having been ruptured and shed when the young root increased in diameter as a result of cambial activity.

Teachers need not become involved in a detailed explanation here. Having explained the anatomy of the typical young dicot root, it is not difficult to show what happens to a root like the carrot wherein the central cylinder increases in size at a much faster rate than the surrounding tissues. These outer layers (epidermis and cortex) are consequently ruptured and lost. The young root thus sloughs off the outer tissues as far inward as the central cylinder which continues to enlarge until it becomes *the* mature fleshy taproot.[1]

The pericycle, which may be considered the outer layer of the central cylinder in the primary root, gives rise to four rows of secondary roots. Naturally after the central cylinder has thickened, the pericycle lies much farther from the cambium. In fact it may be said that the pericycle has been "pushed" to the outside by the new phloem growth and has formed a new external protective layer, the *periderm,* which replaces the epidermis and cortex already sloughed off.

In examining cross sections of this taproot students will soon observe that the branch roots appear to arise from the cambium, or possibly the xylem. These observations will seem to refute the fact that the pericycle gives rise to the branch roots since the pericycle lies so external to the points of branch-root origin in the mature organ. It will not be difficult, however, for students to see that the pericycle was located closer to the center in the very young root and that growth in thickness thus resulted in partial enclosure of these branch roots by the newly formed (secondary) phloem. This

[1] Actually this mature storage organ is not totally root structure as a comparatively small part at the top developed from the hypocotyl of the seedling. It seems hardly necessary to mention this fact to high school students; but teachers will want them to avoid using cross sections cut too near the top since the internal structure varies some in the upper hypocotyl part.

necessitated not only an outward migration of the pericycle but also a continues increase in its circumference.

In order to give students a three-dimensional concept of the xylem structure with its four rows of radiating branch roots, a simple technique may be employed using large carrots: (1) Leave the carrots in a warm dry room long enough to cause them to become somewhat shriveled and easy to bend. (2) Cut off an inch at the top to exclude that part of hypocotyl origin. (3) Make a longitudinal slit with a sharp knife to the depth of the cambium the full length of the carrot. (4) Remove the entire phloem-periderm structure by prying it away with the fingers. This outer structure when removed will show a series of openings left by the branch roots which remain in contact with the xylem. The xylem upon exposure will stand out as an interesting pyramidal structure with radiating projections which are the four rows of branch roots. If these two separated structures are soaked in cold water they will regain their normal size and crispness in a short time.

Conclusion

(1) Esau has shown that the fleshy taproot of the carrot represents *only* the central cylinder of the original primary root.

(2) The part usually labeled "cortex" in many textbooks consists chiefly of secondary phloem, "the original" cortex having already disappeared.

(3) The taproot is covered with a protective layer, the periderm, which originates from the pericycle and takes the place of the lost epidermis.

(4) In certain respects growth in the fleshy root of the carrot is similar to the secondary growth of a woody dicot stem. Therefore, students who understand the fate of the cortex and epidermis in the growth of young woody dicot stems will find no new concept here.

Reference Cited

Esau, K. 1940 *Developmental Anatomy of the Fleshy Storage Organ of Daucus carota.* Hilgardia 13: 175–226.

MICROSCOPIC CRYSTALS MELTED FOR STUDY

A single particle, one-thousandth the size of a pinhead, can be examined and studied by chemists, using a new microscopic technique.

Crystals too small to be seen are melted in a heater under the lens of a microscope. Delicate measurements made when the crystal melts reveal chemical characteristics of the tiny particle.

This method has been described by Dr. A. A. Benedetti-Pichler of Queens College, N. Y.

LARGE CLASSROOM PET-HOUSING

LEONARD S. DAVENPORT
State Teachers College, Cortland, New York

The advantages of having rabbits, guinea pigs, chickens, ducks, etc. in a classroom are too well established to need lengthy treatment here. Budget limitations often force teachers to improvise in curious ways; sometimes with great success. Figure I shows a good pen made from a crate found in a school basement. It could easily have come from a local plumbing establishment or a department store. Notice that "A" shows the chicken wire nailed in the inside of the frame. (This eliminates animal droppings from being deposited on the edge of the woodwork.) In "G" a bottom corner with a sheet metal shield is shown; droppings are conveyed to the tray below. "B" shows a half inch wire cloth stapled so that there is no wood beneath to catch waste, (wire cloth is stapled to the under edge of frame.) "C" shows a galvanized sheet iron box made by a janitor, parent or ingenious instructor. (This item is too difficult and hazardous for young children to make.) Be sure the edges are dull and that the draw is water tight. Hay, dried sugar cane, paper strips, excelsior, etc. may be added to absorb waste moisture. The entire pen-cage should be rested on "D" blocks high enough above the draw to permits its easy removal.

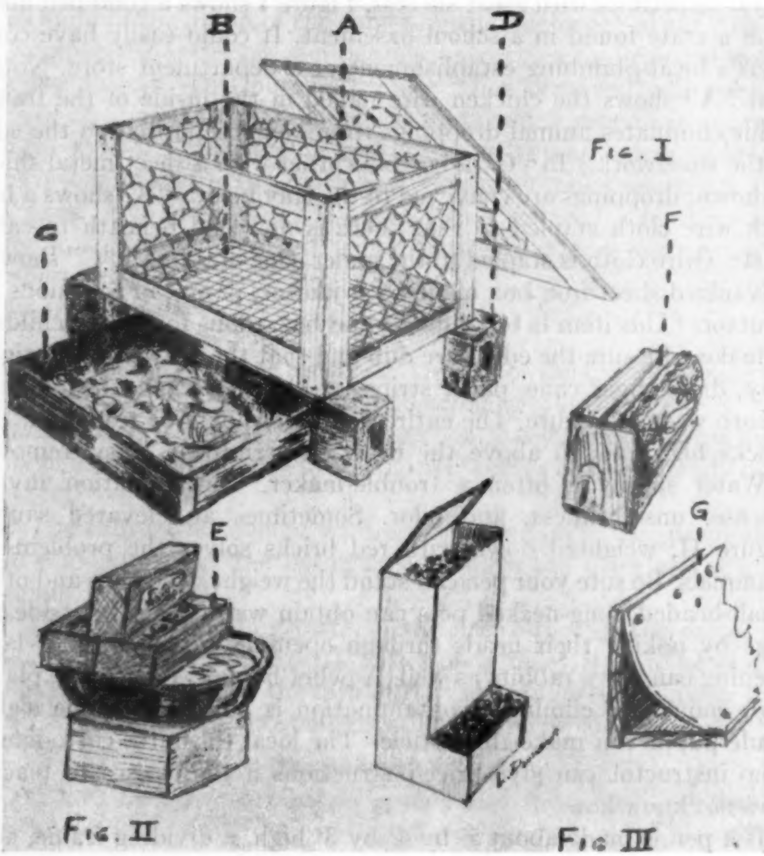
Water supply is often a trouble-maker. Contamination invites disease, unsightliness, and odor. Sometimes an elevated saucer, Figure II, weighted down with red bricks solves the problem for mammals. Be sure your pen can stand the weight. Chickens and other small-headed, long-necked pets can obtain water placed outside the cage by poking their heads through openings in the wire. A large opening can serve rabbits as well. A pellet hopper, Figure III, placed high enough to eliminate contamination is advisable. Some eighth grade pupils can make this article. The local tinsmith, custodian or shop instructor can give brief instructions if the classroom teacher does not know how.

If a pen is made about 5′ by 4′ by 3′ high, a dividing frame, such as the lid in Figure I, can be wired dividing the pen into 2 compartments. Fine wire cloth can be placed in the pen and held with short pieces of spool wire to keep the young from escaping. A small wooden box with a cloth flap provides a good nesting place for a mammal. The low front board beneath the cloth prevents the young from leaving the nest.

Pupils can be taught to take care of pets and cage needs. They should be instructed to keep out of the pen for several reasons,—the wire mesh can not stand the weight of a child, school clothes will become soiled, and pens should not become vehicles of child play. A

scrubbing brush, a paint scraper and a household or farm deodorant-disinfectant should be bought.

Care should be taken to see that no wooden surface is left uncovered. Any glossy surface such as is obtained by using a good varnish, enamel, or paint fosters satisfactory sanitary conditions. The first sign of rust in the draw should result in its being painted. A piece of tar paper under the entire pen aids in keeping a good floor



A HOUSING PROJECT FOR THE SCIENCE ROOM

clean and unscratched. The pen can be set up in any room on short notice and as easily removed. A well painted box to house pets during cleaning time should be provided.

Once one pen is made, parents, custodians, and friends in local men's clubs can usually be prevailed upon to supply other cages like the original. The endeavor pays dividends in deep pupil-teacher satisfaction. No dividends can be expected to contribute more.

THE UNAPPRECIATED USEFULNESS OF MATHEMATICAL COMPOSITION*

R. L. EDWARDS
Miami University, Oxford, Ohio

Short-cut solutions of many equations by the use of mathematical composition justify increased attention to this long neglected operation. A brief review of the fundamental algebra involved might be helpful. Given

$$a/b=c/d. \tag{1}$$

Adding the numeral 1 to both sides of the equation, we have

$$a/b+1=c/d+1$$

and obtaining common denominator

$$\frac{a+b}{b}=\frac{c+d}{d}\,. \tag{2}$$

On comparing eq (2) with eq (1) we see that (2) might have been obtained directly from (1) by adding denominators to numerators, and that the operation is entirely general. On inverting eq (1) we have

$$b/a=d/c \tag{3}$$

and on inverting eq (2) we have

$$\frac{b}{a+b}=\frac{d}{c+d}\,. \tag{4}$$

Comparing eq (3) and eq (4) we see that numerators can always be added to denominators. Eq (3) may also be written in the form

$$b/d=a/c \tag{5}$$

and (4) as

$$b/d=(a+b)/(c+d). \tag{6}$$

We see that eq (6) would have been obtained from eq (5) by adding numerator to numerator and corresponding denominator to denominator, likewise always permissible.

If we had subtracted the numeral 1 from eq (1) instead of adding same, and performed operations similar to those above, we would

* Part of this paper is an elaboration of "A Neglected Algebraic Operation" by the same author in *The American Journal of Physics* for July–August 1947, page 356.

have justified the use of corresponding differences instead of sums. Thus, if $a/b=c/d$, if follows that

$$\frac{a\pm b}{b}=\frac{c\pm d}{d}, \quad \frac{a}{b\pm a}=\frac{c}{d\pm c} \quad \text{and} \quad \frac{a}{b}=\frac{c\pm a}{d\pm b}\cdot$$

A few illustrations of equations solved by the utilization of these simple operations show the conciseness obtained as compared with the conventional cross multiplying, transposing, refactoring and division, most of which operations represent separate algebraic steps.

Case 1. In determining the distance x to a fault in a line of total length $2l$, a Wheatstone bridge gives the relation

$$\frac{x}{2l-x}=\frac{R_1}{R_2},$$

which we wish to solve for x. Add numerators to denominators obtaining

$$\frac{x}{2l}=\frac{R_1}{R_1+R_2},$$

and multiply by $2l$, giving

$$x=\frac{2lR_1}{R_1+R_2}\cdot$$

Case 2. Since the electron has a mass that is appreciable as compared with the mass of the nucleus, the electron does not revolve around the nucleus as a center but both revolve around their common center of mass. If a is the radius of the electron orbit, A that of the nucleus and r the distance between electron and nucleus, we have $r=a+A$. We wish to determine the value of a in terms of r, the mass of the electron and that of the nucleus, m and M. From the equality of centripetal forces we have $ma=MA$ or $a/A=M/m$. Adding numerators to denominators we have

$$\frac{a}{A+a}=\frac{M}{m+M}\cdot$$

Multiply the equation by r, remembering that $a+A=r$, and we have

$$a=r\,\frac{M}{m+M}\cdot$$

Another illustration of the same type is furnished by the problem of obtaining the fraction of the total current flowing through a shunted galvanometer. Here

$$\frac{i_g}{i_s}=\frac{R_s}{R_g} \quad \text{and} \quad I=i_s+i_g.$$

Case 3. If we solve for r in the defining equation for the eccentricity of a comic section, $\epsilon=r/(d-r\cos\theta)$, we obtain like coefficients of r by multiplying numerators by $\cos\theta$; we then add numerators to denominators, cancel the $\cos\theta$ which has now served its function of "catalyst", and multiply by d, obtaining $\epsilon d/(1+\epsilon\cos\theta)=r$.

Case 4. In deriving the equation of the brachistochrone, we have $q^2/(1+q^2)\ (u^2-2gy)=c^2$, which we wish to solve for q, the reciprocal of the slope. We multiply by (u^2-2gy), and subtract numerators from denominators, obtaining

$$q^2=c^2(u^2-2gy)/[1-c^2(u^2-2gy)].$$

Case 5. A case of special interest to students in physics is the establishment of the angle of minimum deviation for the refraction of a ray by a prism. On differentiation of the angle of deviation with respect to the angle of refraction at the first surface, we obtain as in the conventional proof,

$$dD/dr_1=\frac{\mu\cos r_1}{\sqrt{1-\mu^2\sin^2 r_1}}-\frac{\mu\cos r_2}{\sqrt{1-\mu^2\sin^2 r_2}},$$

substituting r_2 for $(A-r_1)$. This expression must equal zero for a minimum to exist. Transposing and squaring, we have

$$\frac{\mu^2\cos^2 r_1}{1-\mu^2\sin^2 r_1}=\frac{\mu^2\cos^2 r_2}{1-\mu^2\sin^2 r_2}.$$

Subtracting numerators from denominators, we have

$$\frac{\mu^2\cos^2 r_1}{1-\mu^2}=\frac{\mu^2\cos^2 r_2}{1-\mu^2}$$

since the sine squared plus the cosine squared of an angle always equals 1. Since r_1 and r_2 must be acute angles their equality for a minimum is established.

Case 6. Suppose we have an equation of the form

$$\frac{ay}{bc+dx}=\frac{ex+fy}{gh+lx}$$

which we wish to solve for y. We obtain like coefficients of y by multiplying numerator and denominator of the left hand member by f, of the right hand member by a, and subtract numerator from numerator and denominator from denominator, obtaining

$$\frac{fay}{f(bc+dx)}=\frac{a(ex+fy)}{a(gh+lx)-f(bc+dx)}.$$

Cancel the f from the left hand member and the a from the numerators. Solution is completed by multiplying the expression by the denominator of the left hand member.

In all the cases listed, the entire solution is readily accomplished without making any of the ordinary algebraic steps, but by merely "doctoring up" the initial equation.

NOTES FROM A MATHEMATICS CLASSROOM

Joseph A. Nyberg
Hyde Park High School, Chicago

142. Arithmetic as a Preparation for Algebra. There is a general belief that a good foundation in arithmetic is essential for a good start or preparation in algebra. Hence some teachers begin the course in algebra with a review of arithmetic, with particular attention to fractions and decimals. Acting on the same assumption, some schools assign those pupils who are weak in arithmetic (as revealed by diagnostic tests) to classes in General Mathematics. The question of "arithmetic as a preparation for algebra" could stand investigation.

We would first need to agree on a definition of algebra and to state the objectives of the course. Not wishing to write the hundreds of pages that are necessary to state the objectives, I shall use a few words from page 268 of *Butler and Wren's The Teaching of Secondary Mathematics* (McGraw-Hill Book Co.). " . . . in contrast to arithmetic, algebra is more concerned with the conscious examination and study of processes than with particular answers to particular problems . . . " and " . . . algebra is . . . characterized by a much higher degree of generalization and abstraction."

That quotation sets a high standard for any class in algebra, and many schools will feel that only a small percent of their pupils could do the work that it implies, and that the majority of the pupils cannot do much more than learn the formal operations. So we can put the original question in two parts:

(1) Is a good foundation in arithmetic needed in such exercises as:
Multiply $3x^2-6x+4$ by $5x-3$.
Divide $8x^3-12x^2+6x-1$ by $2x-1$.
Add $3a^2+5a-4$ and $-a^2-7a+8$.
Factor $21x^2+2x-8$. Solve $3x=18-2(x-1)$.

(2) Is a good foundation in arithmetic needed in such problems as: Generalize and solve the problem: If John can do a job in 6 days, and Henry needs 8 days to do the same job, how many days will they need if both work?

No one will disagree with the statement that the pupil who has done good work in arithmetic will very likely do good work in algebra. And so our question really amounts to this: If a pupil shows that his foundation in arithmetic is poor, how much time and energy shall be spent at the beginning of the year to correcting this deficiency as a preliminary to whatever kind of algebra he is about to study? My own answer is "None."

My principal reason is that the deficiencies in arithmetic can be corrected gradually throughout the year. When learning to add, multiply, and divide signed numbers, I need not restrict the work to integers but can use decimals. When solving equations I need not limit the work to equations like $6x=24$ but can use

$$6x=\tfrac{1}{2} \qquad 1.2y=.72 \qquad 2\tfrac{1}{2}n=10 \qquad 6\tfrac{1}{4}w=\tfrac{1}{3}.$$

(Parenthetically, I may add that I see no need to solve the last equation by clearing of fractions or using any multiplier. I can divide $\frac{1}{3}$ by $6\frac{1}{4}$.) Checking the solutions of equations furnishes much review of arithmetic. When evaluating algebraic expressions more drill with fractions and decimals is possible. And these are only a few of the instances for arithmetic review.

It is true that this is an unpopular method for maintaining the skills of arithmetic. In textbooks most equations have integral solutions. The teacher marks with a red pencil those equations with fractions for solutions, and carefully avoids them. Teachers do not like the fractions and decimals because such answers upset the class routine, cause digressions, and necessitate a review of arithmetic.

But there are teachers who agree that the type of work I have mentioned should not be dodged, and they begin the year with a review of arithmetic. These teachers do not wish the work in algebra to be interrupted or sent off on a tangent by some pupil who cannot add two fractions. They want the pupil to know his fractions so well that he can add them whenever occasion arises at any place in the year's work. As they say, "When I teach equations, I don't want to teach arithmetic. When I teach formulas, I don't want to teach arithmetic. When I teach quadratics, I don't want to teach arithmetic."

I can sympathize with these teachers, and I hope that gradually they will become accustomed to the inevitable interruptions. Pupils can learn best when there is a felt need for what they are studying. When the class is learning to add signed numbers and make mistakes with fractions, I interrupt the work to say, "I see you can add the

whole numbers easily but not the fractions. So let us set aside algebra for twenty minutes and review the addition of fractions." And when the class can solve $ax = b$ for integral values of a and b but not for fractional values, I interrupt the work to say, "Let us set aside algebra for a day, and review division of fractions." And likewise in a dozen other places during the year. Even the "story problems" need to be preceded by similar problems that can be solved by arithmetic.

143. General Mathematics as a Preparation for Algebra. Pupils with I.Q.'s of 90 or less are usually advised to enroll in general mathematics rather than algebra. The counseler usually adds. "and then you can take algebra the following year." The assumption is that the pupil is not intellectually able to learn or profit by beginning algebra at once, but that a year later he will be able to do so.

If parents, superintendents, and tax payers would allow teachers and counselers to be truthful, the latter would say to the pupils, "Don't ever take algebra. You haven't the brains for it. Don't think of going to college; but if you find one that will admit you, then specialize in some field that requires no mathematics or science."

The general mathematics will of course give this pupil much useful and interesting information, but, in the words of *Butler and Wren*, it does not prepare for a conscious examination and study of processes in contrast with finding particular answers to particular problems. Algebra is a study of generalizations, and the pupil who is unable to generalize will not succeed in real algebra.

After completing a year of general mathematics, the pupil is allowed to enroll in algebra. I wish more schools had the courage to allow these pupils to enroll in geometry rather than algebra. These pupils are not likely to reach any position in industry in which a knowledge or ignorance of either algebra or geometry will alter their lives or influence the national welfare. But the geometry can be made more interesting to them than algebra. Although geometry also requires ability to generalize and to use generalizations, the low I.Q.'s can grasp the geometric generalizations more easily since they can be illustrated with figures and models. Further, geometry is less ab-abstract. And, since I am expressing wishes, I wish that this pupil with the low I.Q. could take his geometry during his third year rather than his second.

144. The First Day in Algebra. When possible (and I say *when possible* because high school life has become a succession of interruptions, emergencies, and expeditious adjustments) I like to begin a new class with something that will catch the pupil's imagination, something that will startle him and make him talk about that class at the dinner table that evening. If I were a chemistry teacher I fear I would have an explosion in the laboratory the first day; if a zoology

teacher, I would arrange to have an elephant walk in. In this respect algebra is lacking in possibilities. But above everything I would not announce that we are to begin a review of some old material.

Years ago the problem of making an explosive start was easier, for then the eighth grade teachers were satisfied to teach arithmetic and did not feel that they should begin algebra "to make it easier for you when you get to high school." In those days I began with the problem of finding an average of some numbers by the method of guessing an average and then finding how much each number in the list was above or below the average. A statistician calls it averaging the deviations. This problem furnished an easy introduction to signed numbers, and was interesting to the pupils merely because it showed a new attack on an old problem. It gave the pupils something to talk about that was *new*. This problem is no longer appealing since the eighth grade teachers teach signed numbers.

One of the problems I now use is based on the seesaw. A boy weighing 80 lb. sits at one end and a boy weighing 90 lb. is at the other end. The seesaw is 10 ft. long. Where shall we place the fulcrum so that the lever will balance?

We begin by guessing that the fulcrum is 4 ft. from the heavier boy, and test the result. They try 5 ft., and test the result; try $4\frac{1}{2}$ ft., and test the result; and so forth, keeping an eye on the clock so that the bell will not ring before the experiment ends. Finally I explain that there is a method that eliminates guessing and experimenting, namely, using a symbol to represent the desired distance, using an equation, and so forth. They have had some experience with equations but not with the kind that I write (since it uses parentheses).

Naturally the pupils do not understand how I solve the equation but they can leave the first day with some notion of how algebra differs from arithmetic. And for a class in pedagogy I can suggest as a term paper: Find other suitable ways of beginning an algebra class without having an explosion or importing an elephant.

PHOTOCELL DETECTS CARBON MONOXIDE

Carbon monoxide, which can be even more dangerous in airplanes than it is in automobiles, is detected photoelectrically in the device on which patent 2,425,059 has been awarded to William F. Fagen of Chicago, assignor to the Stewart-Warner Corporation. A continuous sample of the air supplied to the plane's cabin is passed through a tube containing a gel that turns dark blue in the presence of carbon monoxide. A light beam that passes through the gel in its normal state is dimmed, hence fails to excite the photocell on which it is directed. This change in current, suitably stepped up, operates a relay and gives warning.

A UNIT IN AVIATION IN GRADE SIX

EDWARD P. POWERS
Larkfield School, East Northport, New York

All science teaching, particularly on the elementary level, should have significance and play a functional role in the life of the child. The teaching of facts without underlying concepts or relationships does not give to this subject the vitality it otherwise could have.

Often the opportunity to teach something of real interest and value to the child springs up incidentally in the ordinary routine of teaching, and the instructor should make the most of it.

THE MOTIVATION

While in the process of completing a unit in grade six, one of the students happened to bring in a model plane which he had built. It was a rather good plane and we put it on the shelf for the classes to admire. During the science period, discussion ensued "just on airplanes." Needless to say, discussions of this nature create high interest in most boys and girls.

One student suggested that we study about airplanes, and the teacher, taking the cue, asked them what they would like to know about airplanes. The children suggested these problems:

1. How does an airplane fly?
2. What are the parts of planes?
3. How is an airport operated?
4. What has been the history of aviation?
5. How are airplanes constructed?
6. How do balloons and dirigibles fly?
7. How does a pilot control a plane?
8. What instruments are used on a plane?
9. How has the airplane changed our way of living?

PLANNING THE WORK

With these problems set up for solution, another discussion ensued as to the best means for solving each problem with the facilities available. In nearly every case, these were the suggestions given by the children with a minimum of guidance by the instructor:

Problem 1. Ask one of the teachers who was taking flying lessons to talk to us about this problem. Show movies that might deal with the subject. Read books on the subject.

Problem 2. Make model airplanes and then, as we make them, study them. Discuss the parts when finished and, if

possible, have an "air meet" on the playground.

Problem 3. Visit LaGuardia airport, which, luckily, is nearby. Make a model airport in the classroom.

Problem 4. Do reading on this subject. Show movies about it.

Problem 5. Visit a nearby airplane plant. Write to other companies that build planes and ask for booklets on the subject. Have an exhibit of materials used on planes.

Problem 6. Collect pictures of balloons and dirigibles. Do reading on the subject. Do experiments to show why things float. (This last was a suggestion of the teacher.)

Problem 7. Get a model plane with controls and operate them. Do related reading on the subject. Show movies.

Problem 8. Find pictures of instruments. Do reading to find out how they work. Do any experiments that we can with them.

Problem 9. Write to airplane companies for information. Show any related movies on the topic. Discuss our findings in class.

This was the period of planning. It took about three days to make plans for the study of the unit. There was a minimum of teacher guidance, and in so far as possible the teacher kept in the background, making a suggestion where it was felt needed.

Executing the Plans

The following phases of this study developed:

The children selected the problem they wanted to work on, and on this basis they were divided into nine groups with an average of three in each group. Each group was to solve its problem by doing research from the books we had available in the library.

We decided to start with each child building a model plane purchased in kits from local stores.

While the planes were being built, in the science period the children of the various groups discussed with the teacher ways and means of solving their problem. The instructor made suggestions.

When the planes were finished, they were suspended from the ceiling with thin wire. Some surprisingly good work had been accomplished. Many had never built a plane before.

Next the children divided into their groups and from the library table selected reading on their topic and condensed this material into a report.

Then began a period of reporting, followed by activities. The following is a summary of what was done by each group.

Results of Group Study

Problem 1—How does an airplane fly?

Based on their reading and on two movies which were secured for them—"Aircraft and How They Fly" and "Motions of a Plane" (Bray Pictures Corp.), this group presented the simple principles of flight. To aid in this, the children did simple experiments with air and, with help from the teacher, did some experiments which illustrated the principles of flight. They asked the teacher who was taking flying lessons to come in and answer questions about the problem. (The principles of flight can be found in "Elementary Science for the Air Age," by Charles K. Arey—Macmillan Co.)

Problem 2—What are the parts of planes?

This was a problem for the entire class. In building the planes the children discovered much about the various parts. Students who had had experience in building planes assisted others. When the work was finished, the important parts of the planes were discussed. The purpose of each part was also discussed and the children took notes for their science notebooks. A flying meet was held on the playground as a part of this problem.

Problem 3—How is an airport operated?

The group did selected reading in the library on this topic, and reported their findings. At the same time they presented a model airport made on cardboard with painted runways, hangars, model lights, etc. This proved to be so interesting that the class went on an excursion to LaGuardia Airport, where the children were taken on a conducted tour. Needless to say, this was a thrilling experience.

Problem 4—What has been the history of aviation?

This group presented an interesting story of the history of aviation, using material secured from the library. They also presented a mural which showed the highlights of this history.

Problem 5—How are airplanes constructed?

The group wrote to several aircraft companies asking for information on how planes were built. As this material was received, the group condensed it into a report illustrated by the booklets and pictures. Materials used in plane construction were collected by this group and presented with the report. Culminating this report was a visit to a nearby aircraft company where the children were taken on a conducted tour. A movie was also shown: "The Story of Willow Run."

Problem 6—How do balloons and dirigibles fly?

The children in this group collected pictures and mounted them. In their reading they found the history of lighter-than-aircraft and present-day uses of them. To help the class understand why dirigibles stay up in the air, the group did experiments which they had planned with the teacher.

Problem 7—How does a pilot control a plane?

This was related to the movie "Motions of a Plane" (Bray Pictures Corp.). The children had read "Planes in Action" (Harper and Brothers) and presented a summary of their findings. One of the students, who was able to procure a model plane with controls, operated these controls to demonstrate the basic motions of turning, diving, climbing, and banking.

Problem 8—What instruments are used on a plane?

Using the book "Parts of Planes" (Harper and Brothers) the children made sketches of various instruments. As they showed their pictures they discussed how the particular instruments helped the plane. They performed simple experiments with a compass and a toy gyroscope, and examined an aneroid barometer and discussed its function on a plane.

Problem 9—How has the airplane changed our way of living?

Based on their research this group presented an interesting report showing the use of planes in modern living. They had written to a number of airlines and secured an ample quantity of free material which they read and then placed on the bulletin board. This made an attractive exhibit. Using this material they made their report.

Evaluation

In conclusion a test was given, based on the material presented in the various reports. The results of this were excellent. This was an average class who took time to plan the unit with the teacher. As a result of this planning an interesting unit, timely in nature and appealing in quality was worked out. The instructor takes little credit, for he has found that with careful preparation the children can be of great help in planning the instruction.

Editor's Note: Two series of books which teachers have found useful for pupils in the study of aviation are these:

(1) Young America's Aviation Library, by Aviation Research Associates—Harper and Brothers.
Titles available:
How Planes Fly

Party of Planes
Types of Planes
How Planes Are Made
Planes in Action
(2) Aviation Readers—Macmillan Co.

SUBJECT MATTER AND EDUCATIONAL OBJECTIVES

ISIDOR AUERBACH
Lafayette High School

ABRAM BADER
Midwood High School

ALLEN A. REICH
Pershing Junior High School
Brooklyn, New York

The classroom teacher of science, surveying the curricular progress in the last decade, may indeed feel confident that the objectives are being definitely delimited. It is still true, however, that theory and practice are not always in consonance. The active life and program of a school frequently do not agree with the stated objectives. The teacher needs to translate the general aims into the daily practice of the classroom. It is rare for curricula to indicate the specific subject matter than can be used to realize the aim stated. There is vital need for indicating classroom situations in which desired behavior characteristics can be developed. The statement of the desired behaviors is not enough.

A recent report states:

> "Students who are in the habit of formulating real problems and of insisting on genuine solutions, who know how to judge, collect, and interpret data, who are not misled by inaccurate or spurious statistics, and who know how to recognize valid proof, will not easily be misled by propaganda, suppression of evidence, systematic calumny, demagoguery, or mystical symbols."

What subject matter would be most useful in developing these concepts? The following classroom situations are suggested as being well suited for the development of the four aims stated in the quotation above.

A. *Habit of formulating real problems and of insisting on genuine solutions.*

In developing this concept the class is led to see that a genuine solution has the following characteristics.

1. It answers the problem.
2. It predicts the results of future experimentation.
3. It explains apparent contradictions.

4. It leads to new problems.

The method suggested is to consider a proposed solution, show it to be false, and then discover a genuine solution.

Case 1. Demonstrate that a wooden block suspended from a spring balance, and lowered until the block floats in water, will give a reading of zero on the balance. Metals may be similarly floated, using mercury as the liquid. The question, how much do floating objects weigh, will almost invariably elicit the response that floating objects weigh nothing, or that they lose all their weight. Ask the class to use this solution in predicting the result of the following experiment. A beaker half filled with water is placed on a dietician's scale. What will the scale read if a piece of wood suspended from a spring balance is placed on the water? If a floating object loses all its weight, there should be no change on the dietician's scale when the wood floats in the beaker. When the experiment is completed, the class will see that the spring balance reads zero, while the dietician's scale reading increases by the weight of the wood. The class can see the falsity of its solution. The weight of the wood is not lost. The wood is supported by the water. The genuine solution is that the floating object is supported by an upward force equal to its weight. Can this solution explain why an iron ship floats in water, while an iron block sinks? Why do metals lose only part of their weight in water? Why is the loss of weight different in different liquids? The solution of these problems leads the students to a formulation of Archemides Principle, the definition of specific gravity and an appreciation of the difference between a genuine and false solution.

Case 2. After a study of incandescent lamps, toasters, fuses, electrical cigarette lighters, and other electrical heating appliances, the question is posed; where is most heat generated in electrical circuits? The standard demonstration showing heating of copper and iron wires in series will bring the explanation that more heat is generated in the higher resistance. The fact that high resistance wire is used in the above-mentioned electrical appliances will seem an apparent proof of the statement just given. Now connect the copper and iron wires in parallel, and compare the heating effects produced. As a further check, have a class connect 40- and 100-watt lamps in parallel and measure the heat evolved by immersing the bulbs upside down in calorimeters. The class will conclude:

(a) In a series circuit, (current the same) the greater resistance develops more heat.

(b) In a parallel circuit, (voltage the same) the circuit with more current, and therefore less resistance, develops more heat. The generalization that heating depends on both current and resistance will lead to the true solution that the heat varies with I^2R. With V

constant (parallel circuit) more heat will be developed in the lower resistance because current enters into the equation as a squared factor. The class can then explain the apparent paradox of using high resistance wire in low resistance electrical heating devices as toasters, fuses, etc.

Case 3. Chemistry teachers find this type of error very prevalent when classes are shown the burning of wood, paper, coal, and sulphur. The ash left, when weighed, seems to prove that substances burning in air lose weight. Their observations of the ash from coal furnaces as compared with the weight of the coal consumed seems another proof of that belief.

The problem can be solved by asking the class to explain the results of burning steel wool, magnesium, or copper, with an increase in weight in each case. The class can then see the necessity of accounting for the gaseous products in the first experiment. Combustion experiments with the carbon dioxide formed, absorbed in sodium hydroxide, will convince the class that the true solution of the problem of burning in air is that the total weight of all the products, is greater than the original fuel. The class can then apply this result to the further study of oxidation.

Case 4. In the attempt to simplify some concepts for students, a half truth may be accepted by the student as a true explanation. He is then completely unprepared for the collapse of his generalizations when he attempts to apply them to other situations. Elementary classes in general science and chemistry are shown the demonstration of a glowing splint thrust into a bottle of oxygen, bursting into flames. From this the student accepts as a test for oxygen the bursting into flame of a glowing splint put into a colorless gas. When nitrous oxide is used as a test gas, his two criteria, colorless gas, and a glowing splint bursting into flames, are both satisfied, and unless he introduces further specifications to his test he will call nitrous oxide, oxygen. The two gases may be differentiated and a more nearly correct test for oxygen discovered by the class, if pure nitric oxide is introduced into a bottle of oxygen and one filled with nitrous oxide. A student can then state the conditions for the proper test. The gas must be colorless, cause a glowing splint to burst into flame, and turn nitric oxide brown before he can be sure it is oxygen.

A similar instance is the test for carbon dioxide. After the demonstration of carbon dioxide putting out a flame, demonstrate that other gases will do the same, for example, nitrogen. Clarify the half-true solution, by showing that carbon dioxide turns limewater milky (if not introduced in excess) and that both the extinguishing of a burning splint, and the test with limewater, are necessary for a satisfactory test for carbon dioxide.

B. *The report specifies "a student should be able to judge, collect and interpret data."*

The development of such abilities necessitates knowledge and practice by the student. The class must be allowed time to weigh the importance of the possible variables in an experiment. It is the responsibility of the class to determine the relevance of possible factors. The method of the experiment, and the form in which the records and results will be tabulated, should also be left to the decision of the class. Almost universally the laboratory manuals and work sheets completely specifiy the factors to be varied and the type of data to be recorded. The ability to decide what are the pertinent facts is extremely important. It is usually completely neglected. Training in the desired ability may be developed by the following suggested procedures.

Case 1. Discussion of bombing problems, objects falling from buildings and the path of projectiles may be used to motivate the problem of falling bodies. In determining how far an object will fall with increasing time, the class may be asked to list all the possible variables that may affect the result. A typical list might contain size, weight, temperature, friction, material of the object; color, time of day, air pressure, wind velocity. If we roll a ball down an inclined plane, the width, thickness, angle with the horizontal, and friction of the plank may all be included. The class can specify what factors are to be kept constant and determine the variation between time of fall and distance. Each of the factors mentioned may be varied in order and data collected. From these data the class can determine the relevant factors and interpret the data collected for the formulation of the law.

Army bombing tables for various sizes and weights of bombs, a bombing slide rules taking account of the air temperature and pressure, show that these factors, usually neglected by the average class discussion, are important for accuracy in real situations.

Case 2. The problem of determining the general law for balancing weights on a lever should also be attacked by first asking the class to list the relevant factors. Such a list might contain the following: weights, distance of the weights to the fulcrum, distance of the weights to the end of the stick, shape of the lever, weight of the lever, temperature, and atmospheric pressure. The class can then decide, as a first step, to fix the size and shape of the lever by using a meter stick. Temperature and pressure may be noted for later experiments with different pressures and temperatures. There will be a real division of opinion on the question whether the distances are to be measured to the fulcrum or to the end of the stick. Allow the class to experiment and decide which distance measurements will prove valuable. In the usual experiment manuals, the students are not given the

experience of deciding what factors are pertinent. By a series of experiments, the class will then formulate the relationship between the weights and distance to the fulcrum. The law of moments can then be developed, by experiment, for more than two weights. The effect of the weight of the lever, and the idea of the center of gravity should be developed by the class for a final formulation of the conditions for equilibrium of a lever.

Case 3. The demonstration of conduction of electricity by electrolytes may well raise the question, what determines which substances in solution act as conductors and on what do their conductivities depend? The class could list such items as temperature, valence of ions, concentration, type of chemical used, color, purity of chemical substance, degree of disassociation, etc. Careful tests will enable the class to determine which chemicals conduct and to which chemical categories they belong. Further study by the class of the effects of each pertinent item in the list above would be valuable. The relationship of concentration to conductivity of an acid as well as that between conductivity and degree of ionization should help the class understand the Debye-Huckel theory of ionization.

Case 4. In discussing the halogen family or other similar family in the periodic table, the problem of correlating the members' activity with other chemical or physical properties, would be a good opportunity for collecting, judging, and interpreting data. The class would again be put on its own resources in thinking out properties that may or may not correlate, gathering pertinent data and interpreting results. Such properties might be atomic weight, atomic number, atomic size, physical state, color, concentration of ion, and valence of ion. Again the emphasis is to be placed on allowing the class the multiplicity of choices with the opportunity for determining the pertinency of each factor listed. Training in a cut and dried, teacher-directed solution is of very little help to the pupil in the formation of habits of scientific thinking.

C. *The report further states "who knows how to recognize valid proof."*

In the discussion of the nature of a valid proof, some of the common errors to be studied are:

1. False use of analogy.
2. Non-consideration of pertinent data.
3. Check experiments too limited in scope.

In another paper some illustrations of these errors have already been given.* The teacher may prove true statements by experiments that are actually invalid. A demonstration of the greater resistance of iron wire as compared to copper, by measuring the voltage drop

* Auerbach, Isidor, et al., "Teaching the Scientific Attitude," SCHOOL SCIENCE AND MATHEMATICS, November, 1941.

across a long iron wire and comparing it to that across a length of copper wire is not valid unless the class uses the same length, diameter, and temperature in each case. This may be illustrated by first using a long thin length of iron and a short thick copper wire. With the class convinced of the greater resistivity of iron, reverse the conditions by testing the voltage drop when the copper wire is long and thin and the iron wire short and thick. The necessity for careful consideration of the elements of a valid proof will be clearly demonstrated.

Case 1. Analogies are very frequently helpful in explaining a new topic but the use of them often leads to false conclusions. Reasoning by analogy must be very carefully limited to be valid. In explaining the flow of electrical current through resistors, the water analogy is very frequently used. In considering the voltage drops in a series circuit, the similar drop in water pressure in a water circuit is often used. This analogy if applied too closely is false. Consider three resistors connected in series with the largest resistor connected between the other two. The water analogy given might be a large cross section pipe followed by a constricted section and then a pipe of larger cross section again. Using the water comparison, the student may be tempted to say that in checking voltages around the electrical circuit we would find a drop across the center one and then a rise across the third. He would say this, because he would remember Bernoulli's principle. This would give a large pressure drop to the constricted section due to the increased velocity of water flow. Actually the potential drops continually in an electrical circuit. The error here is to attempt to apply Bernoulli's principle derived from the consideration of a frictionless non-dissipative energy flow, to an electrical circuit where resistance is present and electrical energy is transformed to heat.

D. *The fourth item to be considered is that of training the student "in detecting spurious or inaccurate statistics."*

In many cases the student feels that his experimental data must yield a perfect answer, and any data he records must fit a curve or conclusion without error. This feeling he soon carries over to an attitude that what he sees in print must be true. A critical attitude should be developed so that the student can detect false and inaccurate statistics.

Case 1. Acetamid or naphthalene is often used in experiments to show that the melting point of a crystalline solid is constant during the change of state. The students record the readings of a thermometer in a test tube filled with liquid naphthalene. As the liquid cools and changes to a solid, the students find that the readings fluctuate, sometimes rising and falling as much as two degrees instead of staying

at one temperature. This is due to inadequate mixing of solid and liquid in the test tube and liberation of latent heat of fusion. The student who plots such results is often tempted to leave out all the data which will not fit his idea of the results. He should be made conscious of the need for examining the data and explaining his discrepancies. He can then repeat the experiment with proper provisions for stirring. Upon comparison of his results with the rest of the class, spurious and inaccurate data by some students can be easily detected.

Case 2. The method of comparing an individual's data with the class average to reveal spurious and inaccurate data can be applied to experiments on specific gravity. In finding the specific gravity of lead, by the displacement method, a slight error in volume gives a gross error in specific gravity.

Case 3. Experiments in which false data can be easily checked are those in which the result cannot exceed a definite value. In finding the specific gravity by the use of the pyknometer, the students are asked to find the specific gravity of water, copper sulphate and brine solution. Any error in the specific gravity of water is immediately evident. In one case a student found a value of 1.8 for water. Such an obviously false result made him recheck his method and he found the error in his calculation. He had failed to subtract the weight of the bottle from the combined weights of bottle and liquid in finding the weight of the liquid used.

Case 4. Similar results are obtained by students in such experiments as the inclined plane and pulley experiments. Errors in the readings of the spring balances often give apparent data showing the output to be more than the input. Such a result immediately serves as a check on inaccurate work. This result may also be obtained if the student reads the spring balance while it is in a position for which it was not calibrated, e.g., upside down or at an angle to the vertical.

Case 5. The development of a critical attitude towards data may be tested by showing the class an unfamiliar machine, e.g., a Spanish Burton pulley arrangement, and then giving the class false readings of the effort required in its operations. The class should be able to detect the spurious values. A critical attitude towards data should be encouraged so that much of the present advertising claims be carefully considered by students. The ability to detect spurious or inaccurate data will be needed throughout the life of a student.

This article has attempted to show the concrete subject matter which may be used to implement the objectives in our science course. Much more work is necessary before each classroom teacher has a detailed and comprehensive plan for the development of those habits in our students which all educational authorities advocate.

TODAY TOMORROW BUT SURELY SOMETIME

Erna Grassmuck Gilland

Secretary, Committee on Geographic Education for World Understanding, National Council of Geography Teachers

In a statement of his belief in the United Nations, Warren R. Austin, Chief U. S. delegate to the U. N., said in part, "We are engaged in a whole series of constructive activities to build lasting peace through the United Nations—We must seek out and support the patient, constructive ways of building peace."

Meaningful, purposeful, continuous education can be one of these "patient, constructive ways." As Howard E. Wilson, then Deputy Executive Secretary of the United Nations Educational Scientific and Cultural Organization (UNESCO) said at the Endicott, N. Y. meeting of the World Conference of the Teaching Profession, August 1946, "Education is now and will be a continuing primary interest in UNESCO." (UNESCO is an inter-governmental organization and has the status of a specialized agency within the United Nations framework.) In this great plan geographic education has definite responsibilities, opportunities and contributions.

Today, as well as *tomorrow* and in the future, the people of the United States should know definitely how to utilize geographic information in analyzing and aiming to understand and solve local, state, national, and international problems. One wonders how many do really know! How many realize to what great extent the present and especially the potential geography of the Soviet Union is basic for that country's current behaviors in the United Nations affairs?

Also, how many United States citizens are utilizing geographic information in seeking solutions for most of our national problems? How few are considering the potential geography of the United States of America in urging major state and national decisions today!

Pupils in elementary and secondary schools are today developing correct, or incorrect, concepts of the "nature" environments of the stories they are being told and read. Some are being permitted to develop an attitude of indifference (or even prejudice) towards these nature settings. In too many classrooms, instead of experiencing vital geographic education, the youngsters are still being required to memorize and recite facts, often merely locations or isolated items of description, that may have been true, or half-true, in the past.

Functional geographic education means growth within the learner whereby he or she discovers and enjoys tracing geographic relationships. For example, he finds the geographic relationships between the work, or recreation, in a given place and the related elements of weather, climate; terrain and other land features as soil, rocks, minerals, native vegetation; native animal life; various water and air resources. To understand these geographic relationships, the learner must also be acquiring correct, meaningful concepts of each individual nature item and human (or culture) item that is involved. Otherwise his performance is merely a jumble of words with little or no constructive carry over into his own behaviors and attitudes.

In geographic learning, skills in the use of pictures, specimens, objects, globes, maps, word matter and statistics of real geographic quality are achieved. So also are wholesome attitudes towards efficient and honest study habits and constructive recreation interests, in and out of the classroom; openmindedness towards places and peoples, nearby and afar; willingness to share one's own possessions with those who need them and will appreciate such sharing; and other constructive attitudes.

Today, especially in secondary schools and colleges, students should have opportunities to learn the present and potential geography of their own country and the various phases of world geography, and to apply these geographic understandings in the analyses and solutions of local, national and international problems. Though in many secondary schools and colleges these opportunities are not offered today, they will be *tomorrow* or surely in the *near future*.

Geography is a science of relationships between man and the natural environment in specific regions. It requires clear-cut concepts of the individual nature and culture items involved—features, activities and conditions. Its basal organization is *regional*. Geography has its own distinctive disciplines. Hence it is not merely a social science. It is the liaison field of knowledge between the social studies and the natural sciences. Geographic relationships involve items from both those fields. A survey, being currently made, shows that greater emphasis on developing more accurate and complete concepts of "nature" items is definitely necessary in geographic education.

What of geographic education? Today many currently-accurate data are available concerning the geography of the United States, Canada and certain parts of the other American countries; Australia, parts of Europe, Asia, Africa, and Polar regions. *Tomorrow* data of geographic quality will become in-

creasingly available for other parts of the Americas, Eurasia, Pacific and other island regions and Polar areas. ***But surely sometime*** sufficient, accurate and complete geographic information on the Soviet Union and the present unexplored areas in the world, must also become available for all peoples or there cannot be international peace and goodwill on earth. Let us realize that "potential" geography is as significant as present-day geography in the welfare of the world. So also a proper balance in emphasis between national, and international and world geography is essential.

Now as to geographic education. Let there be clear distinction between geography ***per se*** and geographic education. Education implies definite changes in the intellectual, emotional, spiritual, and often physical, structure of the learner. Vital geographic education must produce changes in the very being of the learner. He must see with "geographic eyes" and display geographic understanding in his attitudes and behaviors when discussing and disposing of local, state, and national problems. Persons adequately prepared in essential geographic education can not act indifferently towards international problems. They feel impelled to face these problems frankly and seek fair and possible solutions. *Today* there appears to be tragically little geographic education evident in the lives of most Americans. Teachers and school administrators should be deeply and broadly prepared in accurate geography and in virile geographic education. Children, youth and adults need thoughtful and functional guidance in their respective experiences in geographic education and its applications to the analyses and solutions of day-by-day living problems.

Some possible approaches. The problems of geography and geographic education faced by thoughtful persons throughout the world are numerous and often complicated. Exchange of data, findings and techniques as well as persons will further the building of peace.

As a result of conversations between European and American teachers of Geography, begun in 1935, it has been decided to organize THE INTERNATIONAL GEOGRAPHICAL ASSOCIATION, an international association of teachers of geography, with the object of promoting the exchange of information on the subject matter and methods of teaching Geography and to publish a monthly journal. Its development will require time. Experience with the Geography Section of the World Federation of Education Associations has demonstrated the complications of international activities. Patience, imagination, cooperative

understanding are needed in abundance. But neither of these organizations can achieve certain work which can be done more expeditiously within UNESCO.

However, UNESCO does not include *today*, yet may *tomorrow*, or *surely sometime* a section, guided by a joint group of scientific geographers and of teachers (and students) in geographic education. It might be designated *Geography and Geographic Education* and assist in "advancing the mental knowledge and understanding of peoples through all means of mass communications," "giving fresh impulse to popular education and to the spread of culture."* It could "maintain, increase and diffuse"* geographic knowledge and provide stimuli and avenues for the coordination of the plans and efforts of geographical and educational groups and associations throughout the world. Thus, this Section could help to "assure the conservation and protection of the world's publications, encourage cooperation among the nations and initiate methods for such international cooperation calculated to give the people of all regions access to the materials produced by any of them."*

The scientific geographers would be chosen from carefully selected regions of the world and the teachers (and students) would represent various educational levels: pre-school, elementary, secondary, post-high school youth (collegiate and non-collegiate), adult.

These scientific geographers might provide guidance in preserving, increasing, and disseminating currently-accurate geographic data, about every region throughout the world for which data are procurable. The information should include geographic relationships and the necessary details of the nature and culture items involved and should be expressed in the most advisable media—word matter, pictures, diagrams, graphs, and other statistical form: Summaries of techniques employed in collecting data would also be valuable exchange material.

Additional activities might be the compilation of sources for geographical information; the implementation of means for the exchange of geographers and for scientific correspondence between them; the formulation of plans for the exchange of scientific media and of techniques in exploration and discovery of geographic data; and assistance in conducting international meetings. These scientific geographers could be simultaneously engaged in cooperative undertakings with other groups in UNESCO.

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* Quotations from Article I, Constitution of UNESCO.

The assistance of these geographers would be continuously available to their co-workers, the teachers in geographic education. Together they might assemble pertinent geographic materials for all age levels to use in schools, homes, colleges, churches and elsewhere. Thus greatly needed and desired, functional geographic knowledge and media would become available for authors, publishers, curriculum builders, teachers and others throughout the world. Hence students and lay-folk would have greater opportunities than now exist for acquiring geographic understanding so necessary for building and maintaining international peace.

These materials would be meticulously examined for scientific accuracy and completeness (within current possibilities), teaching ability or learning probabilities, purposefulness at the educational level for which they are intended and for their possible attitude-building value in the achievement of desirable balance between national and international welfare.

These geographic learning media should include thoughtfully selected pictures of various kinds; specimens, objects, models; globes and maps; word matter; diagrams; graphs and other statistical matter. The teachers of geographic education could offer suggestions (1) for assembling and distributing sources for study materials of recognized geographic quality (graded as to learning difficulties); (2) for means of exchanging students and teachers in geographic education and of exchanging professional correspondence; (3) for cooperating with other agencies in arranging international tours for lay-folk and professionals; (4) for implementing and conducting international gatherings of teachers of geographic education and of secondary and collegiate-age students.

The teachers of geographic education in this section would concern themselves primarily with the preservation, increase and dissemination of geographic learning materials; knowledge and media. Techniques and other problems of teaching and learning in geographic education, including the gradation of learning difficulties and evaluations of outcomes in terms of international understanding could receive their close study. They could suggest the elements of effective preparation for teachers in geographic education essential in achieving those goals. They, too, would be available for cooperative activities with other groups in UNESCO.

This section could act as a clearing house for information, programs and coordination of the efforts of individuals and organizations concerned with the kind of geography and geo-

graphic education that will contribute to the objectives of UNESCO.

A *Geography* and *Geographic Education Section* could render valuable consultative services to the eight program divisions in the UNESCO Secretariat organization: Education, Mass Communications, Libraries, Museums, Natural Sciences, Social Sciences, Philosophy and Humanities, and Arts and Letters. It could assist specifically with the four projects of UNESCO currently undertaken by several program divisions in collaboration: fundamental education, education for international understanding, the proposed institute for scientific research in the Amazon Basin, and educational rehabilitation and reconstruction. Because of the very nature of geography and the complexity of problems and activities suggested for the *Geography* and *Geographic Education* section, it should maintain its own entity and not be assigned to any one program division.

Meanwhile *today* and *tomorrow* teachers, students and other interested persons can promote and operate geography workshops in their own localities—in schools, libraries, club-rooms, community-centers, where in combination with learning materials in other fields of knowledge, geographic pictures, books, pamphlets, magazines, films, museum materials, lectures, group discussions and other activities might be made available to persons of all age levels. Thus, geographic and other knowledges that promote national and international understandings would be more accessible in the community.

In his address, at the Mountain-Plains Regional Conference on UNESCO, in Denver, Colorado, May 1947, Charles A. Thomson, Executive Secretary, U. S. National Commission for UNESCO, raised two questions that are indeed pertinent, namely—"Can we work together" and "Can we keep on working." The significant achievements of several scientific organizations throughout the world and of the Geography Section of the World Federation of Education Associations are concrete answers to the first question. In reference to the second, Mr. Thomson said, "Can we mingle with our impatience because of the urgency of the hour, the patience that carries on when the going is hard? Can we equip our resolutions, not only with the keen cutting edge of enthusiasm, but also with a temper that is tough and realistic? When UNESCO does not go exactly as we want, when it may seem to turn perhaps in the wrong direction, will we keep on working? Can we keep our eyes above the dust and yet our feet on the ground? UNESCO will take all we've got, in endurance and devotion."

Certainly we in the United States have had conclusive proof that no one wins a war. Wars are often caused by lack of understanding of the respective viewpoints of the enemies.

When among peoples there is understanding of their varying viewpoints constructive peace is more likely. Effectively geographic education contributes definitely to such understanding.

We are not interested in having another war, but are, or at least should be, vitally interested in using every possible means to make another war impossible or, remotely likely. Prejudices and misunderstandings of adult populations are difficult to combat and often impossible to eradicate. So the most significant and productive procedure that we can follow is to use every opportunity for building more wholesome and tolerant attitudes among the young people throughout the world. Regardless of what this costs in time, effort and money, it can never equal the expense, suffering and heartaches of war.

RENSSELAER EXTENDS TEACHER TRAINING PROGRAM

Because of the nation's shortage of scientific and technological personnel and the shortage of teachers to train such personnel, Rensselaer Polytechnic Institute will immediately devote as many of its facilities as necessary to a wide education program for "more and better high school teachers in science, technology, mathematics, and vocational education."

Under what was described as the only existing program of its kind, RPI will confer two degrees it has not heretofore conferred in its 123 years of existence. They will be bachelor of science in vocational education and master of science in education.

Cooperating in the program are the New York State Department of Education and the State College for Teachers at Albany.

RPI's president, Livingston W. Houston, said that RPI and the two state agencies had decided upon the plan in order to help provide a larger supply of teachers needed to train personnel for the nation's large program for research and development in atomic energy and other scientific advances.

"The shortage of operating personnel which could be recruited for these purposes is serious," he said.

President Houston said the new program would also be of direct benefit to New York State in providing competent teachers for the technical institutes being established in several areas of the state.

MY FRIENDS

How many million friends there are whose lot
Keeps them outside my path for life's short while!
But through the distance and the dark I smile;
For I can love them though I see them not.

—Robert Beverly Hale

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirkville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2040. *A. W. Gordon, Chilton, Wis.; Maria Matthew, Convent Station, N. J.*

2041. *B. Felix John, Ammendale, Md.,*

2047. *Proposed by Stephen Ball, Tecumseh, Michigan.*

Solve for x:

$$(a+x)^{2/3}+4(a-x)^{2/3}=5(a^2-x^2)^{/3}.$$

Solution by S. E. Field, Ironwood, Michigan.

Writing the equation in the form

$$(a+x)^{2/3}-5(a^2-x^2)^{1/3}+4(a-x)^{2/3}=0$$

and factoring, we have

$$[(a+x)^{1/3}-(a-x)^{1/3}][(a+x)^{1/3}-4(a-x)^{1/3}]=0.$$

The first factor gives

$$x=0,$$

the second

$$x=62a/65.$$

Solutions were also offered by Harry Siller, Waterbury, Conn.; W. J. Cherry, Berwyn, Ill.; Max Beberman, Nome, Alaska; Hugo Brank, University of Maryland; John T. Webster, Pullman, Wash.; Raymond Kassler, Forest Hills, N. Y.; B. Felix John, Ammendale, Md.;

2048. *No Solution has been offered.*

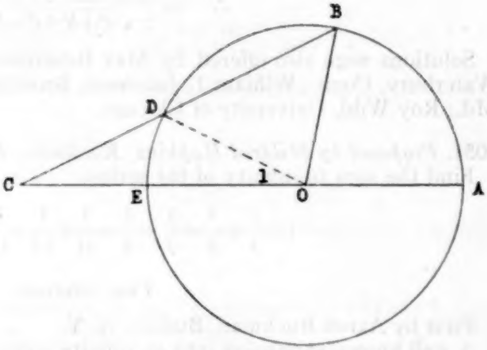
Solution by Max Beberman, Nome, Alaska

2049. *Proposed by Felix John, Ammendale, Md.*

If AOB is any given angle at the center of a circle, and if BC can be drawn

meeting AO produced in C, and the circumference in D, so that CD shall be equal to the radius of the circle, then the angle C will be equal to one-third the angle AOB.

Solution by Max Beberman, Nome, Alaska.



$\angle C = \frac{1}{2}Ba - \frac{1}{2}DE$

$\quad = \frac{1}{2}\angle AOB - \frac{1}{2}\angle DOE$

But $\angle C = \angle DOE$

$\therefore \frac{3}{2}\angle C = \frac{1}{2}\angle AOB$

or $\angle C = \frac{1}{3}\angle AOB$

Solutions were also offered by Donald Fidd, Arlington Heights, Ill.; Margaret Joseph, Milwaukee, Wis.; S. E. Field, Ironwood, Mich.; Hugo Brandt, University of Md.; and the proposer.

2050. *Proposed by Chas. King, Phila., Pa.*

Solve for x, y, z:

$$x^2 - yz = a^2 \tag{1}$$

$$y^2 - zx = b^2 \tag{2}$$

$$z^2 - xy = c^2. \tag{3}$$

Solution by Hugo Brandt, University of Md.

Multiply (1) by y, (2) by z, (3) by x and add

$$0 = a^2y + b^2z + c^2x. \tag{4}$$

Multiply (1) by z, (2) by x, (3) by y and add

$$0 = a^2z + b^2x + c^2y. \tag{5}$$

Multiply (4) by a^2, (5) by $-b^2$ and add

$$x(a^2c^2 - b^4) + y(a^4 - b^2c^2) = 0$$

$$x(b^4 - a^2c^2) = y(a^4 - b^2c^2)$$

or

$$\frac{x}{a^4 - b^2c^2} = \frac{y}{b^4 - a^2c^2}. \tag{6}$$

Multiply (4) by c^2, (5) by $-a^2$ and add

$$x(c^4 - a^2b^2) = z(a^4 - b^2c^2)$$

$$\frac{x}{a^4 - b^2c^2} = \frac{z}{c^4 - a^2b^2}. \tag{7}$$

Call the values of the fractions in (6) and (7) $= t$

$$\left.\begin{aligned} x &= (a^4 - b^2c^2)t \\ y &= (b^4 - a^2c^2)t \\ z &= (c^4 - a^2b^2)t \end{aligned}\right\} \text{ insert in (1)} \tag{8}$$

$$(a^4-b^2c^2)^2t^2-(b^4-a^2c^2)(c^4-a^2b^2)t^2=a^2.$$

Simplified:

$$t^2(a^6+b^6+c^6-3a^2b^2c^2)=1$$

$$\therefore \quad t=\frac{1}{\pm\sqrt{a^6+b^6+c^6-3a^2b^2c^2}}. \tag{9}$$

Solutions were also offered by Max Beberman, Nome, Alaska; Harry Seller, Waterbury, Conn.; William I. Jacobson, Brooklyn; B. Felix John, Ammendale, Md.; Roy Wild, University of Chicago.

2051. *Proposed by Mildred Hopkins, Kankakee, Ill.*

Find the sum to infinity of the series

$$1+\frac{1}{3}+\frac{1}{5}-\frac{1}{7}-\frac{1}{9}-\frac{1}{11}+\frac{1}{13}+\frac{1}{15}+\frac{1}{17}-\cdots.$$

Two Solutions

First by Aaron Buchman, Buffalo, N. Y.

A well known expansion into an infinite series is

$$\text{arc tan } x=x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\frac{x^9}{9}-\cdots. \tag{1}$$

Since this series is convergent if $-1\leqq x\leqq 1$, let $x=1$ and series (1) becomes

$$\frac{\pi}{4}=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\cdots. \tag{2}$$

Multiply both sides of series (2) by 2/3 and it becomes

$$\frac{\pi}{6}=\frac{2}{3}-\frac{2}{9}+\frac{2}{15}-\frac{2}{21}+\frac{2}{27}-\cdots. \tag{3}$$

Add series (2) to series (3) and the sum is

$$\frac{5\pi}{12}=1+\frac{1}{3}+\frac{1}{5}-\frac{1}{7}-\frac{1}{9}-\frac{1}{11}+\frac{1}{13}+\frac{1}{15}+\frac{1}{17}-\cdots$$

which is the required evaluation.

Second by Roy Wild, University of Chicago.

Call the given series s.

Now,

$$\frac{\pi}{4}=1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\cdots \text{ [Leibnitz series].}$$

Also

$$\frac{1}{2}\left(s-\frac{\pi}{4}\right)=\frac{1}{3}-\frac{1}{9}+\frac{1}{15}-\frac{1}{21}+\cdots$$

$$=\frac{1}{3}\left(1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\cdots\right)$$

$$=\frac{1}{3}\cdot\frac{\pi}{4}.$$

Hence

$$s=\frac{5\pi}{12}.$$

Solutions were also offered by **Max Beberman, Nome, Alaska; Howard D. Grossman, New York and the proposer.**

2052. ***Proposed by Roy Wild, Chicago.***

Prove:

$$24\tan^{-1}\frac{1}{53}+20\tan^{-1}\frac{1}{57}-5\tan^{-1}\frac{1}{239}+12\tan^{-1}\frac{1}{4443}=\frac{\pi}{4}.$$

Solution by William I. Jacobson, Brooklyn.

The form,

$$\tan^{-1}a\pm\tan^{-1}b=\tan^{-1}\frac{a+b}{1\pm ab},$$

is used for the simplification of the binomials. The substitutions used are indicated in order of their use.

$$24\tan^{-1}\frac{1}{53}+20\tan^{-1}\frac{1}{57}-5\tan^{-1}\frac{1}{239}+12\tan^{-1}\frac{1}{4443}$$

$$\tan^{-1}\frac{1}{57}+\tan^{-1}\frac{1}{4443}=\tan^{-1}\frac{18}{1013}$$

$$=24\tan^{-1}\frac{1}{53}+8\tan^{-1}\frac{1}{57}-5\tan^{-1}\frac{1}{239}+12\tan^{-1}\frac{18}{1013}$$

$$\tan^{-1}\frac{1}{53}+\tan^{-1}\frac{18}{1013}=\tan^{-1}\frac{7}{191}$$

$$=12\tan^{-1}\frac{1}{53}+8\tan^{-1}\frac{1}{57}-5\tan^{-1}\frac{1}{239}+12\tan^{-1}\frac{7}{191}$$

$$\tan^{-1}\frac{1}{53}+\tan^{-1}\frac{7}{191}=\tan^{-1}\frac{1}{18}$$

$$=12\tan^{-1}\frac{1}{18}+8\tan^{-1}\frac{1}{57}-5\tan^{-1}\frac{1}{239}$$

$$\tan^{-1}\frac{1}{18}+\tan^{-1}\frac{1}{57}=\tan^{-1}\frac{3}{41}$$

$$=4\tan^{-1}\frac{1}{18}+8\tan^{-1}\frac{3}{41}-5\tan^{-1}\frac{1}{239}$$

$$\tan^{-1}\frac{1}{18}+\tan^{-1}\frac{3}{41}=\tan^{-1}\frac{19}{147}$$

$$=4\tan^{-1}\frac{19}{147}+4\tan^{-1}\frac{3}{41}-5\tan^{-1}\frac{1}{239}$$

$$\tan^{-1}\frac{19}{147}+\tan^{-1}\frac{3}{41}=\tan^{-1}\frac{122}{597}$$

$$=4\tan^{-1}\frac{122}{597}-5\tan^{-1}\frac{1}{239}$$

$$\tan^{-1}\frac{122}{597}-\tan^{-1}\frac{1}{239}=\tan^{-1}\frac{1}{5}$$

$$=4\tan^{-1}\frac{1}{5}-\tan^{-1}\frac{1}{239}$$

$$4\tan^{-1}\frac{1}{5}=\tan^{-1}\frac{120}{119}$$

$$=\tan^{-1}\frac{120}{119}-\tan^{-1}\frac{1}{239}=\tan^{-1}1$$

after the proper discussion of quadrant, etc.

$$\tan^{-1}1=\frac{\pi}{4}.$$

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2049. *Grace Gaffner, Gloria Catinchi, Suzanne Laico, Barbara Boden—all of Convent Station, N. J.*

PROBLEMS FOR SOLUTION

2065. *Proposed by Hugo Brandt, Chicago, Illinois.*

If the diagonals of a regular pentagon (inscribed in a circle) are drawn, they outline a star. Compare the area of the star with that of the circle.

2066. *Proposed by D. McLead, Winnipeg, Manitoba.*

In parallelogram, $ABCD$, E is any point in AB, F is any point in DC. AF meets DE in H, and BF meets EC in K. Prove that the line HK bisects $ABCD$.

2067. *Proposed by Gay Eggers, St. Johns, Newfoundland.*

Find the area of the triangle whose sides are $x/y+y/z$, $y/z+z/x$, $z/x+x/y$.

2068. *Proposed by V. C. Bailey, Evansville, Ind.*

In triangle ABC the circumradius bisects the angle between h_c and m_c. Find the maximum and minimum values of angle C.

2069. *Proposed by Norman Anning, University of Michigan.*

Solve the system for x, y, z, w.

$$1+w=xy \qquad p^2+w=xz$$
$$2+z=x+y \qquad q^2+w=yz$$

2070. *Proposed by Belle Conley, Newark, New Jersey.*

Prove that $(x+y+z)^n-x^n-y^n-z^n$ is divisible by $(y+z)\,(z+x)\,(x+y)$ with n odd.

EDUCATION OR PUBLIC IMPROVEMENTS?

The great need now is to encourage some of our ablest young people to enter the teaching profession. For if education is a vital concern of a free nation, it must be in the hands of thoroughly able, wellprepared, wellpaid, emotionally balanced teachers.

Salaries have been raised a great deal in the past two or three years due to the pressure of public opinion. A few states have adopted $2400 as a minimum for qualified teachers; many communities have adopted this minimum although not required by state law. This goal should be achieved by every state and community although it will not be possible unless federal aid is made available.

People will have to decide in many cases whether to build roads, for example, or schools. Roads can wait. Children's minds never wait.

Yes, good schools cost money. But the load is not too heavy for a nation where 60 million are employed at a high level of income. Ignorance is far more costly.

The Public and Education.

BOOKS RECEIVED

Elementary Differential Equations, by Lyman M. Kells, Ph.D., *Professor of Mathematics at the U. S. Naval Academy*. Third Edition. Cloth. Pages xiv+312. 13.5×20.5 cm. 1947. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $3.00.

Surveying Instruments, Their History and Classroom Use, by Edmond R. Kiely, Ph.D. Cloth. Pages xiii+411. 15×23 cm. 1947. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $3.00.

Plants. A Guide to Plant Hobbies, by Herbert S. Zim. Cloth. 398 pages. 13×20.5 cm. 1947. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.50.

Chemistry Made Easy, by Louis T. Masson, *Bachelor of Science, Master of Education, Riverside High School, Buffalo, New York*. Cloth. 416 pages. 13×19 cm. School Science Press, 342 Norwalk Avenue, Buffalo 16, N. Y. Price $1.79. Student-Special volume in Leatherette $1.00.

Teaching Aeronautics in High Schools. A Study of Methods, Principles and Measurements Prepared for the Civil Aeronautics Administration and the American Council of Education. Cloth. Pages xii+419. 13×21 cm. 1947. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $3.50.

Adventures in Algebra, First course, by Murray J. Leventhal, N.A., *Author of a Series of Mathematical Texts and Formerly Head of Department of Mathematics, New York City High Schools;* and Charles T. Salkind, M.S., *Samuel J. Tilden High School; Brooklyn College; Brooklyn Polytechnic Institute, New York City*. Cloth. Pages xiv+380. 14×19.5 cm. 1947. Globe Book Company, Inc., 175 Fifth Avenue, New York 10, N. Y. Price $1.84.

A Handbook on Curves and Their Properties, by Robert C. Yates, *United States Military Academy*. Cloth. Pages x+245. 13.5×21.5 cm. 1947. J. E. Edwards, Ann Arbor, Mich. Price $3.25.

Euclidean Geometry, Its Nature and Its Use, by J. Herbert Blackhurst, *Professor of Education, Drake University*. Cloth. 210 pages. 13×21 cm. 1947. Garner Publishing Company, 615–17–19 Euclid Avenue, Des Moines, Ia. Price $2.75.

Theory of Functions, by J. F. Ritt, *Davies Professor of Mathematics, Columbia University*, Revised Edition. Paper. Pages x+181. 21×23 cm. 1947. King's Crown Press, Division of Columbia University, New York, N. Y. Price $3.00.

Iroquois New Standard General Mathematics, by David H. Patton, *Superintendent of Schools, Syracuse, New York*, and William E. Young, *State Education Department, Albany, New York*. Cloth. Book One, Grade Seven, pages xiii+298+48+viii. 13×19 cm. 1947. Price $1.48. Book Two, Grade Eight, pages xiii+326+52+vii. 13×19 cm. 1947. Price $1.48. Book Three, Grade Nine, pages xix+587. 13×19 cm. 1947. Price $1.96. Iroquois Publishing Company, Inc., Chimes Building, Syracuse, N. Y.

College Physics, by Arthur L. Foley, Revised by J. L. Glathart, Ph.D., *Professor of Physics and Chairman of the Department, Albion College, Michigan*. Fourth Edition. Cloth. Pages xvi+703. 15×23 cm. 1947. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $4.25.

Experimental Physics, by H. Clyde Krenerick, North Division High School, Milwaukee, Wisconsin. Paper. Pages 215. 15×23 cm. 1947.

BOOK REVIEWS

DIRECTED EXPERIMENTS IN BIOLOGY, by Jack Robbins, *Head of the Biology Department, Rhodes School, New York City;* and Alan Wayne, *Science Instructor, New York City High Schools.* Edited by J. B. Marks, *Science Department, Sharon High School, Sharon Pa.* Paper. Pages x+118. 18.5×26.5 cm. 1947. College Entrance Book Company, Inc., 104 Fifth Avenue, New York 11, N.Y.

This manual, except for some of its drawings, is certainly useable and practical. It has been written according to the Foreword to provide "a complete laboratory program meeting the requirements of high school syllabi throughout the country." It includes 56 experiments with tabulated page references to 26 current textbooks.

The individual experiment is organized into five parts: (1) Object, (2) Materials, (3) Procedure and Observations, (4) Observation Drawings and (5) Discussion Questions. The Object is stated and the Materials, listed. There is also a numbered "Observation Column"—a special feature of this manual—in which the student may answer the italicized questions of the Procedure. These questions are intended to guide him "toward the appropriate observation." In some experiments an incomplete table for entering in data replaces the observation column. According to the Foreword each experiment "can be completed in a 45-minute period," except for the Discussion Questions which "may be assigned as home work or may serve as the nucleus of a recitation period."

The experiments cover the usual range of biological principles. Like most manuals such topics as conservation, birds, and wild flowers are not included. However, this is true of some textbooks also.

There are a number of drawings which exhibit inaccuracies, or else carelessness, for example: (1) The vascular bundles of the corn stem on page 14 are drawn so that the xylem and phloem of each are shown about ninety degrees out of their proper alignment with the stem center. (2) The onion skin cells on page 3 show middle lamellae which are in most places wider than the cells walls, which is not at all true if observations are correctly made. (3) Nuclei are shown but the several chloroplasts are omitted from the guard cells on page 14; yet the students are asked, "In what other two parts of the leaf are chloroplasts found?" (4) The contractile vacuoles of a paramecium contract alternately but the illustration on page 25 would lead students to the opposite conclusion, or else confusion. (5) The cotyledon of the corn kernel on page 84 is either omitted or else not clearly shown as a blank space occupies its location. (6) The yellow elastic fibers of the connective tissue on page 9 are not typical as these are usually thicker than the white fibers and occur singly or separated more than clustered. Simplicity is to be favored in diagrams for manuals of this type, but not to the extent that accuracy is lost and confusion caused.

The pages of this manual are punched to fit the ring-type notebook. Each sheet is also perforated for easy detachment. The quality of paper is not suitable for using ink; in fact it does not take pencil erasure too well. An improvement here, if feasible, would certainly help the book.

The authors have produced a manual with several worthwhile features which will be welcomed by many biology instructors.

JOSEPH P. MCMENAMIN

ADVANCED MATHEMATICS FOR ENGINEERS, by H. W. Reddick, *Adjunct Professor of Mathematics, New York University, University Heights;* and F. H. Miller, *Professor and Head of the Department of Mathematics, The Cooper Union School of Engineering.* Second Edition. Cloth. Pages xii +508. 13.5×21 cm. 1947. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

The fact that a second edition of this book (which appeared originally in 1938) has been published indicates that there is an increasing need in schools of engineering for courses in mathematics beyond the calculus and that this particular text has found wide adoption.

Although the book has been reset, it does not differ greatly from the original edition. Many new problems, which stress practical engineering applications, have been added. New features of the text which appeal particularly to this reviewer are: a mechanical-brake problem in the chapter on elliptic integrals, the description of the vibrating string and one-dimensional heat-flow in the chapter on partial derivatives and partial differential equations, and the inclusion of the problem of the vibrating membrane in this chapter. An appendix, in which dimensional analysis is briefly discussed, is another welcome addition.

The topics included in this book seem well selected to fit the interests and needs of engineering students, and the authors have succeeded in presenting the underlying theory without attempting overmuch rigor.

H. S. Pollard
Miami University, Oxford, O.

Musical Acoustics, by Charles A. Culver, Ph.D., *Formerly Head of the Department of Physics, Carleton College.* Second Edition. Cloth. Pages xiv+215. 14.5×21.5 cm. 1947. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

Musical Acoustics first appeared in 1941, a book designed to give musicians an elementary knowledge of the physical laws which govern their subject. This book was so clearly written and the subject matter so well presented that little change is necessary. But a few paragraphs needed amplifying, a very few sentences needed correcting. In the revised text an important addition has been made in the discussion of harmonics in different instruments, the action of a sound analyzer has been added, some of the diagrams and photographs of wave forms have been greatly improved, the section on the vocal organs has been enlarged, and some of the results of Dr. Fletcher's investigations are given. A final chapter on recording and reproduction of music has been added. In general all the alterations and additions greatly improve an already good book. A few additional changes should have been made; e.g. the diagram of the wave form of clarinet tones has been improved but that of the oboe remains as before—a very poor photograph. At another point a discussion of the Dopplar effect has been added—a topic which the author states "has no particular significance in music." Then why mention it at all in this book? But the book remains one of the best short texts for students of music. The author has given the essentials only, thus holding to his original objective of writing a text that will be used by music students.

G. W. W.

Relativity, the Special and General Theory, by Albert Einstein, Ph.D., *Professor of Physics in the University of Berlin.* Translated by Robert W. Lawson, D.Sc., F. Inst. P., *University of Sheffield.* Cloth. Pages xiii+168. 13×20.5 cm. Copyright, 1920, Reprinted, 1931. Hartsdale House Inc., 220 West 42nd Street, New York 18, N. Y. Price $2.50.

This is an old book now coming out in a new coat. It was first published in the United States and in England in 1920, but was not given great attention because its content did not seem of much importance to the general public. Recent developments have shown that it does concern the ordinary man, and any reader with a good high school education can read it. Practically all elementary physics courses now recognize Einstein's great contribution to modern physical thought, hence his original, clear explanation is here made available to all. We present it with the great author's wish: "May the book bring some one a few happy hours of suggestive thought." Possibly now after more than thirty years he may want to change the "some one" to "many" and add to the "suggestive thought" an addition wish for practical values.

G. W. W.

College Physics, by Arthur L. Foley, Revised by J. L. Glathart, Ph.D., *Professor of Physics and Chairman of the Department, Albion College, Michigan.*

Fourth Edition. Cloth. Pages xvi+703. 15×23 cm. 1947. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $4.25.

An excellent text now made better. Probably no textbook of college physics has appeared in recent years that has had so great a following as Foley's *College Physics*. This is because of its forceful but simple style, clear discussions, superb figures, and excellent problems, all in the language of a man who had made the teaching of elementary college physics his chief job for nearly a life time. It certainly was a major task for anyone to attempt to improve it. But Professor Glathart has accomplished this. He attacked the book where it was weak and has produced a better book in many ways. His first job was in mechanics. Here he has changed the order of approach. Probably many teachers prefer to start the subject with the material given in chapter 5, but the author has given an improvement over the former volume by using the following order—velocity, acceleration, work, energy—rather than as in the parent text. Many other changes in order of topics will be found in this first division of the subject but a comparatively few changes in language or style. The last section, Modern Physics, has similarly been changed greatly, here often by the addition of new developments or discoveries.

Another great change comes in reversing the order of the discussion of heat and sound. More schools prefer to follow mechanics with heat rather than sound because of the time required for the two divisions although sound is closely related to mechanics. In much of the remainder of the book few changes have been made. In the new book the chapter on the "Chemical Effects of Electric Currents" has been placed later in the text. Some important additions have been made as in the present ideas of magnetic *domains*, a discussion of the cathode ray oscilloscope, and brief mention of the uranium "pile."

Most of the diagrams of the former book have been retained. They cannot be improved. The omission of the "swimmer's rule" for direction of a current will be unanimously approved. But why not make farther improvement by omitting the diagrams of the three classes of levers since no discussion is given or needed? Also in the subject of sound, why go through a great list of relations in working out a major scale when it can all be done very directly with major triads? As a further criticism, the reviewer can see no advantage in setting all problems in the back of the book instead of at the close of chapters as in the previous text. Other questions one might ask are, why use *mechanical* efficiency in the topic heading but only efficiency in the discussion; and just how would the sea gull fly over the *hemisphere* on page 29?

G. W. W.

CAMPING AS A PART OF THE SCHOOL PROGRAM

Publication of "Camping and Outdoor Experiences in the School Program" was announced by the United States Office of Education, Federal Security Agency.

School camping activities are developing from summer to year-round outdoor programs, as illustrated by extensive provisions made in Michigan and California, the bulletin points out.

The 40-page Office of Education bulletin reports steady growth in the movement to provide camping and outdoor experiences for children in elementary schools. Chief advantages of having such programs in the schools, according to the bulletin, are that they help to show the need for changing current curriculums, provide a natural and realistic setting for education, and develop in simple direct fashion and practices of democratic living. Many different types of camping and outdoor experience, now available in our schools, are described.

Copies of "Camping and Outdoor Experiences in the School Program" may be obtained by purchase for 15 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Do you make regular use of Mr. Miller's THE QUIZ SECTION *or* THE PROBLEM DEPARTMENT *conducted by Professor Jamison? Try these on your science or mathematics classes and note the results.*

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